POWER PLANT ENGINEERING

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A Plant Built for Service

SERVICE IS THE PRIME REQUISITE IN THE POWER PLANT OF THE SOLAR REFINING COMPANY

THE CONSTRUCTIONAL features of a power plant in general will be found to vary in accordance with the service to which it is to be adapted. In a large central station, for instance, where power is generated primarily for selling purposes, a high degree of efficiency is, of course, of paramount importance. Attractiveness is also given due consideration in such plants and, as a rule, considerable expense is incurred in making them pleasing to the eye.

At a large oil refining plant where everything is smoky and the entire surroundings covered with a layer of black greasy oil, it is obvious that little time nor expense can be wasted on any elaborate architectural features of the power plant. Such a plant is built for service—24 hr. a day uninterrupted service. No time is spent on embellishment and even efficiency is sacrificed at times to secure the degree of service demanded.

The new power plant of the Solar Refining Company at Lima, Ohio, is an excellent example of the latter type of plant and exemplifies modern practice in this particular field. In accordance with the above stated requirement, this plant, while operating at a high efficiency, was built primarily for hard, continuous service, and during the time that it has been in operation it has met this requirement with no small degree of success.

It is essentially a steam generating plant, supplying steam for power and heating purposes throughout the refining plant. Only a relatively small amount of power

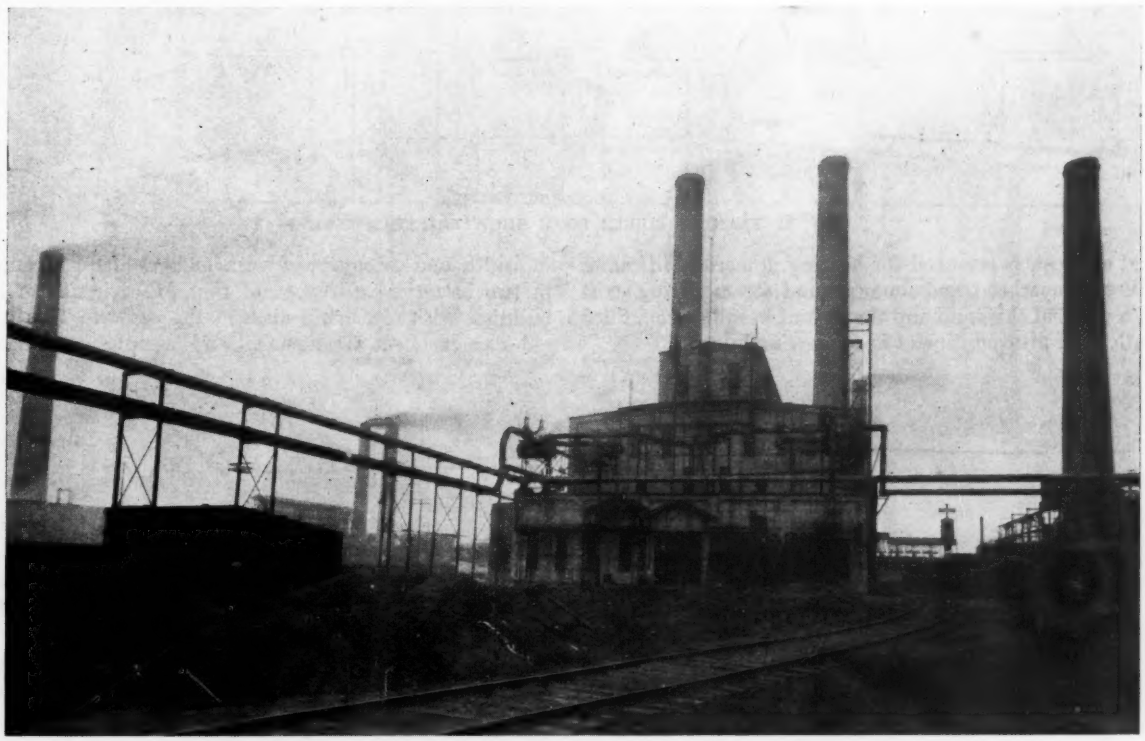


FIG. 1. EXTERIOR VIEW OF POWER PLANT SHOWING OUTSIDE STEAM HEADERS

is used at any particular point; most of it is sent through overhead pipe lines to oil pumps, water pumps, agitators, etc., located at various points throughout the works. In addition, a vast amount of steam, both live and exhaust, is required for heating numerous oil tanks. Miles of overhead and underground steam piping exist in a plant of this kind and the task of keeping them filled with high-pressure steam is not a simple one.

The Boiler House

The boiler house, shown in the photograph, Fig. 1, is a four-story building, 83 ft. high by 116 ft. long, of steel and reinforced concrete construction. It is 88 ft. in width and is equipped with eight boilers, arranged in two batteries; a battery of four on each side of the building with the firing aisle in the center. This provides an excellent arrangement and occupies a minimum

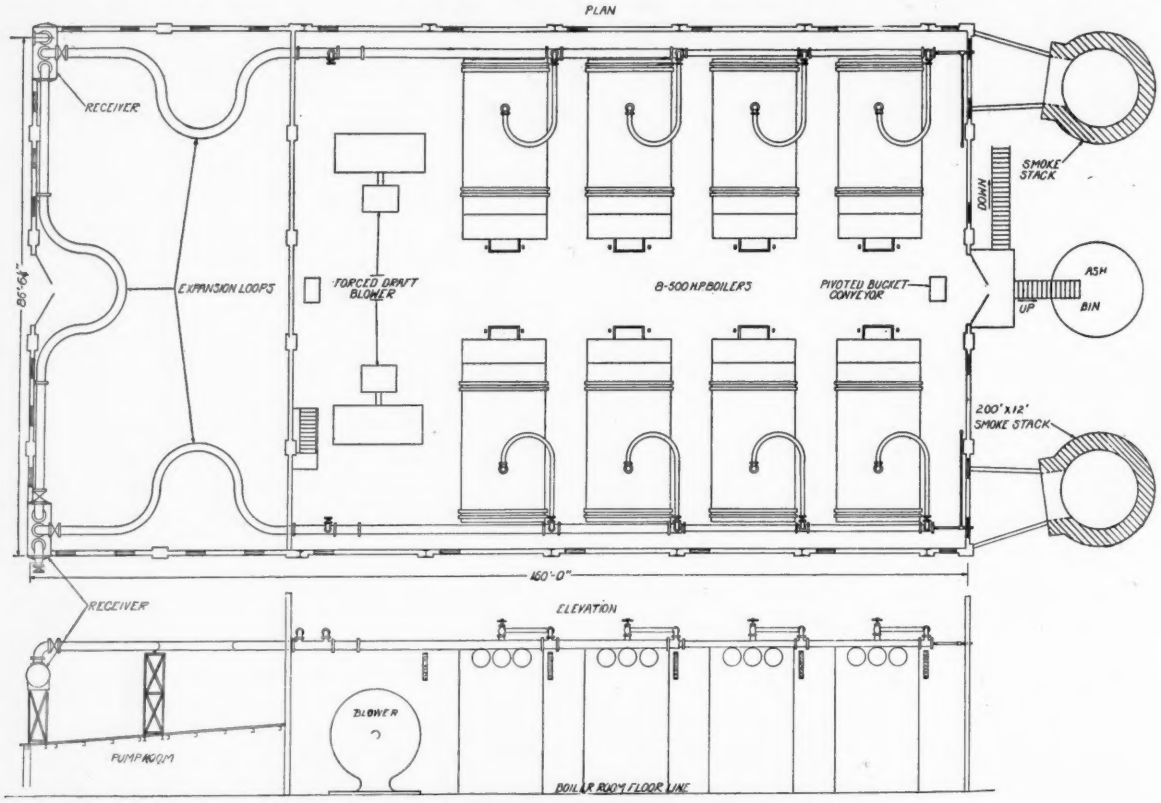


FIG. 2. PLAN OF BOILER ROOM SHOWING STEAM PIPING

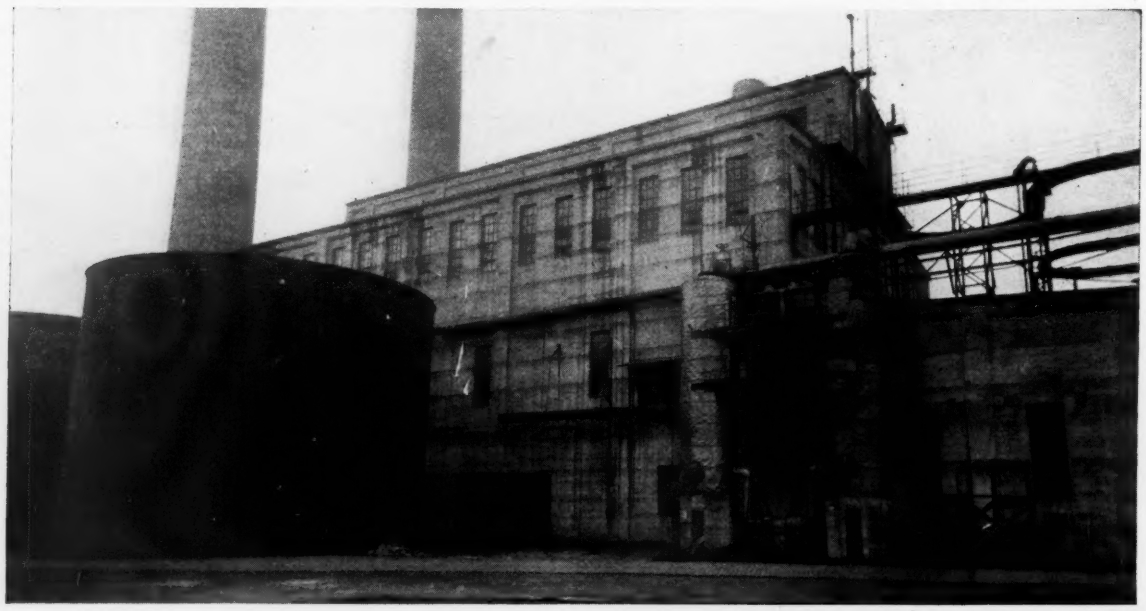


FIG. 3. VIEW OF OUTSIDE FEED-WATER HEATER AND STORAGE TANKS

amount of space. Two 200 by 12-ft. perforated radial brick chimneys remove the products of combustion and provide the necessary draft above the grates. Each chimney serves one battery of boilers.

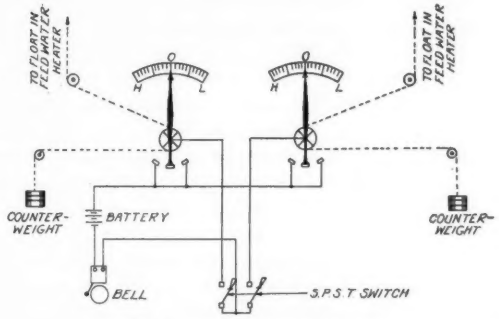


FIG. 4. FEED-WATER ALARM

The eight 500-hp. boilers are all of the water-tube type and are fitted with automatic underfeed stokers. Forced draft is supplied to the furnaces by two 10-ft. blowers each direct connected to a 14 by 12-in. vertical engine. When operating at 286 r.p.m., each blower is capable of delivering 100,000 cu. ft. of air per minute under a static pressure of 5 in. Each blower furnishes air to a battery of four boilers, which, under ordinary operating conditions are run at about 175 per cent of their rated capacity. All boilers are fitted with both indicating and recording steam gages as well as draft gages and water-level alarms.

The blower engines and stokers are controlled from the steam pressure by automatic regulators.

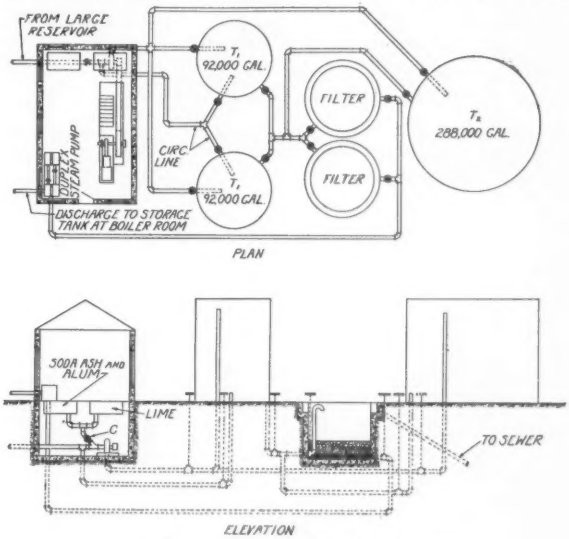


FIG. 5. WATER-SOFTENING PLANT

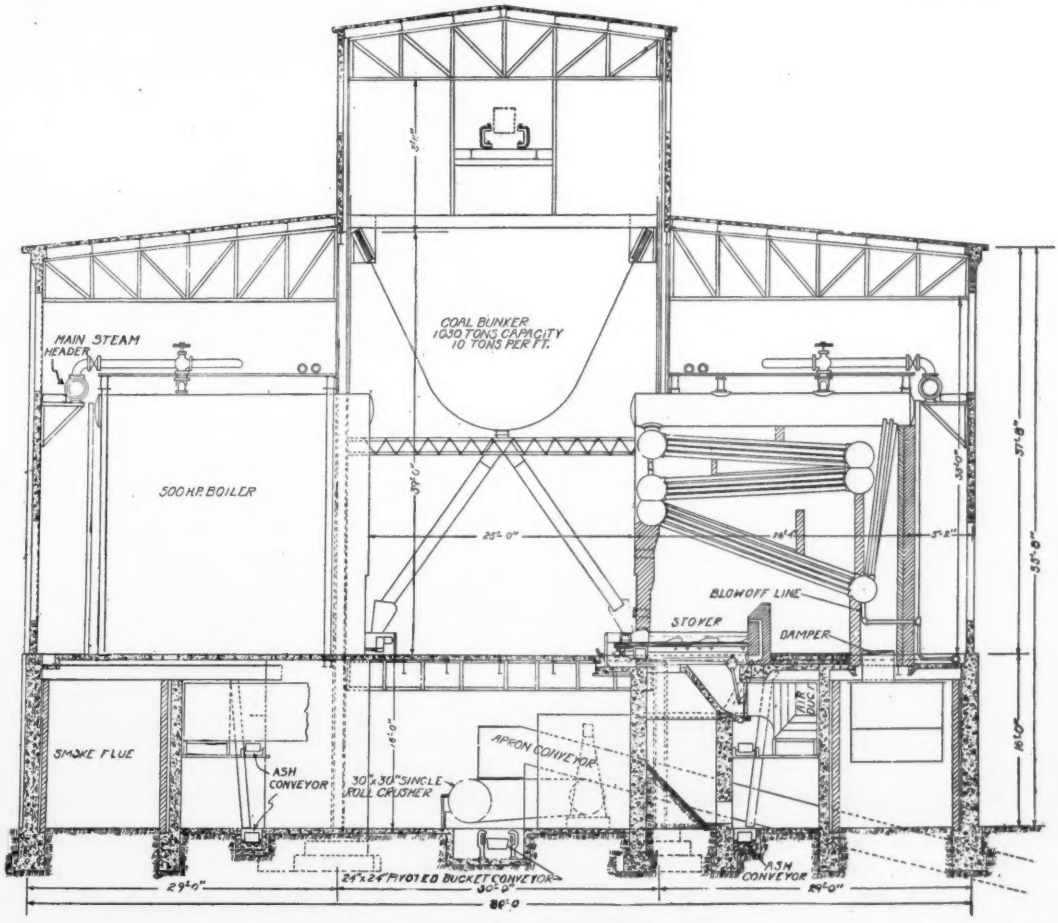


FIG. 6. SECTION THROUGH BOILER HOUSE

Steam Piping

The steam header arrangement in this plant is of exceptional excellence and possesses some peculiar features not commonly encountered in power plant practice. As may be noted by referring to Fig. 2, each boiler delivers steam through individual 180 deg. bends to common steam headers, one header running along the rear of each line of boilers at an elevation of 24 ft., 9 in.,

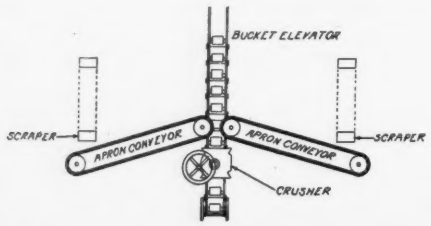


FIG. 7. DIAGRAM OF ASHES-HANDLING EQUIPMENT

above the boiler-room floor. At the forward end of the boiler room, these headers pass through the wall to the exterior of the building above the pump house, and are connected together to form a loop. This is shown clearly in Fig. 2. To allow for variations in length and to avoid stresses due to expansion, this loop has included in it three large expansion bends, as shown. A receiver or separator is located at each corner of this header loop for the purpose of removing any water which might be carried over from the boilers. The main steam distributing headers are connected to these receivers as may be seen in the photograph.

To prevent excessive condensation losses in the outside steam lines, all exposed piping is effectively covered with a double thickness of 85 per cent magnesia insulation, thoroughly waterproofed. This outside piping is supported on structural steel supports mounted on the roof of the pump room.

Outside Feed-Water Heaters

Another feature of particular interest at this plant is the peculiar location of the two large feed-water heaters. Due to space limitations, these heaters are located on the outside of the building as shown in Fig. 3. They are of the closed type and receive water from the two large feed-water storage tanks shown at the left in the photograph. Being exposed, it is evident that unless thoroughly insulated a great deal of heat would be radiated from the heaters; they are, therefore, covered with 3 in. of 85 per cent magnesia over which is applied an oilcloth covering to exclude moisture. All piping and valves relative to these heaters are easily accessible from platforms constructed between them for the purpose.

To notify the engineer or water tender on duty in regard to the water level carried in the feed-water heaters, the electric alarm, shown diagrammatically in Fig. 4, is employed. The two indicators which are connected to floats in the heaters through a system of pulleys are mounted on the wall of the engine room. When the water level is normal, the pointers indicate zero but when the water level rises or falls the indicator moves to the right or left as the case may be. At the same time electrical contact is established between the lower end of the pointer and the fixed contacts, thereby closing the alarm circuit.

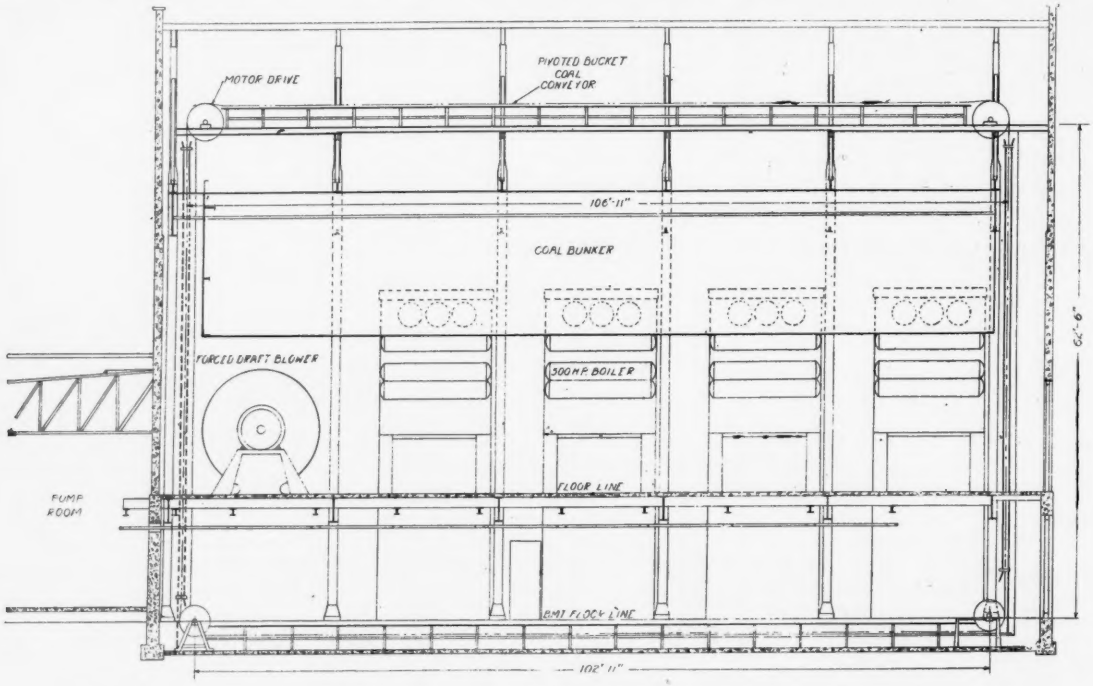


FIG. 8. LONGITUDINAL SECTION THROUGH BOILER ROOM SHOWING PIVOTED BUCKET CONVEYOR

Feed-Water Treatment

As practically no condensate from the various steam lines is returned to the boilers, an enormous quantity of feed water is used. The average daily consumption is about 400,000 gal. Since river water is used, and since this is hard, it is necessary to soften it before

delivering it to the boilers. An extensive water-softening plant is therefore provided where 400,000 gal. of raw water are treated daily.

The treating plant is shown in Fig. 5 and consists of a treating house, two 92,000-gal. mixing tanks, one 288,000-gal. mixing tank, two filter tanks, and a large reservoir into which river water is pumped for settlement preparatory to being treated. The softening process is as follows:

A 1500-g.p.m. steam-driven centrifugal pump located in the basement of the treating house takes suction from the settling reservoir and discharges into either the small tanks T_1 or the large tank T_2. While a tank is being filled with raw water in this manner, the charge of chemicals which has previously been prepared in two chemical mixing vats, is introduced into the suction line of the centrifugal pump. This is accomplished by merely opening valve C shown in Fig. 5. Under ordinary conditions, the chemical charge necessary to treat 92,000 gal., the capacity of a small tank, consists of 145 lb. of soda ash, 125 lb. of lime, and 5 lb. of alum. The

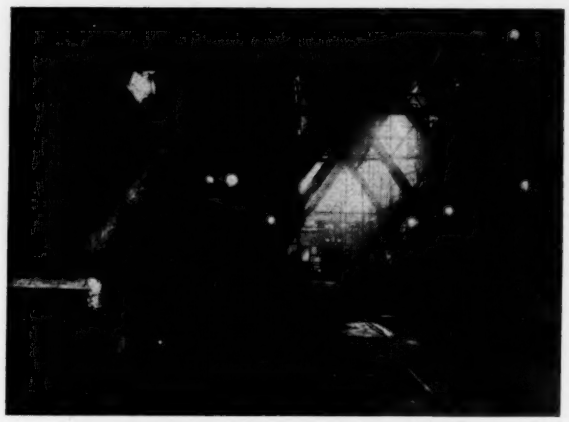


FIG. 9. INTERIOR VIEW OF BOILER ROOM

lime is mixed in one vat and the soda ash and alum in another; the two mixtures are then introduced into the treating tanks as previously described.

As soon as the treating tank is fully charged, the pump suction from the reservoir is closed and the pump suction connected to the circulating line indicated in Fig. 5. It is thus possible to circulate the water continually through the treating tank until a thorough mixture is effected. If desired, however, compressed air may be employed to agitate the mixture instead.

When thoroughly treated, the water is allowed to enter the filter tanks and after passing through various layers of gravel is finally pumped to the storage tanks near the boiler room previously referred to. These storage tanks are about 800 ft. distant from the treating plant.

Coal and Ash Handling

Coal is delivered from railroad cars into a track hopper at the side of the boiler house directly onto an apron conveyor, shown in Fig. 6, which in turn delivers the coal to a steam driven crusher. After passing through the crusher, it discharges into the buckets of a pivoted bucket conveyor. This apparatus may be seen in the photograph, Fig. 10, which shows the 30 by 30-in. single roll crusher installed directly above the 24 by 24-in. pivoted bucket carrier. The latter travels a rectangular path with the lower run along the basement floor, the upper run above the overhead parabolic coal bunkers, and the ascending and descending runs along the walls. The coal is thus elevated and distributed in the overhead bin by the carrier buckets, the discharging of the

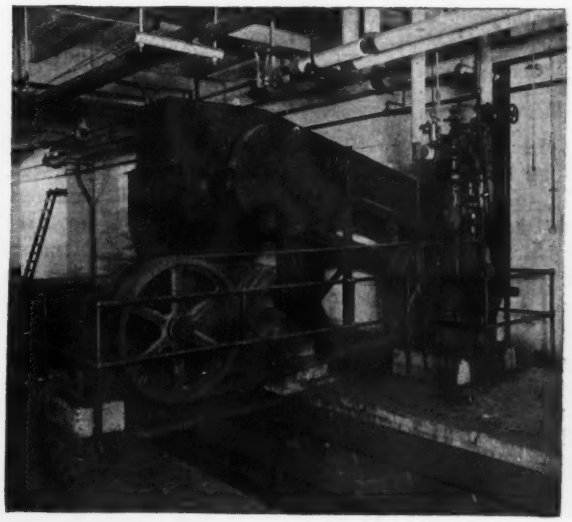


FIG. 10. VIEW IN BASEMENT SHOWING LOWER RUN OF CARRIER WITH ITS STEEL SKIRTS LOCATED DIRECTLY BENEATH THE SINGLE ROLL CRUSHER

buckets being accomplished by a movable tripper running on a T-rail below the upper run of the carrier. Figure 11 shows the upper run of the carrier with the movable tripper in dumping position.

To provide for emergency or unforeseen conditions, an outdoor coal storage pile of approximately 6000 tons

FIG. 11. VIEW ABOVE OVERHEAD COAL BUNKERS SHOWING UPPER RUN OF CARRIER AND TRAVELING TRIPPER

is maintained in back of the boiler house. This storage space is equipped with a cable drag, delivering coal to a bucket elevator which, in turn, discharges into cars or trucks for delivery to the boiler room. Since the daily consumption of coal is about 200 tons this reserve will insure at least a month's operation.

Ashes is handled by two scraper conveyors, one for each line of boilers. These conveyors run the length of the boiler-room basement and discharge onto two apron conveyors operating at right angles to the scrapers. This arrangement is shown in the sketch, Fig. 7. The apron conveyors deliver the ashes to a crusher which is provided to reduce the ashes to a fine consistency to facilitate its flowing from the ash storage hopper, to which it is elevated by a bucket elevator after being crushed.

The Engine Room

In comparison with the boiler plant, the engine or pump room as it is termed at the plant, is not very large, due to the fact that the greater part of the steam generated is transmitted to distant points throughout the works. In addition to the two direct-current generators which furnish current for lighting, the engine room contains three air compressors and a number of pumps such as boiler-feed and service pumps. The three air compressors furnish air at a pressure of 100 lb. and have a combined capacity of approximately 4200 cu. ft. of air per minute. Compressed air is used mostly to operate air lifts supplying water for condensing purposes in the oil stills.

The boiler-feed pumps are turbine driven, of the three-stage centrifugal type and, when running at 2100 r.p.m., are capable of supplying 600 gal. of water per minute under a 400-ft. head.

A separate pump is provided for pumping water from the feed-water storage tanks to the feed-water heater. This is also a centrifugal turbine-driven pump supplying 600 g.p.m. under a 40-ft. head at a speed of 1750 r.p.m.

As exhaust steam is used for a number of different heating purposes, all engines with the exception of one air-compressor engine, operate non-condensing.

As stated in the beginning of this article, this plant was built for service. Its outstanding feature is its ruggedness of construction. Operating under unusually severe conditions, in an atmosphere laden with soot and smoke from scores of chimneys, the cleanliness which characterizes large plants as a whole may be lacking to some extent here. It is not a show station, however, and could not be under existing conditions; but it renders the high degree of service for which it was designed with remarkable success and, furthermore, it does it efficiently. An average evaporation of 9.6 lb. of water per lb. of coal is maintained under all normal conditions.

Methods of Recooling Condensing Water---III*

Cooling Towers; Their Theory and Principles of Design. By The Terrell Croft Engineering Company

A COOLING TOWER consists, essentially, of a tall, narrow, wooden or sheet-iron structure, so arranged internally that after the warm condensing water has been elevated to the top under pump-pressure, it will fall, by gravity, in a multitude of thin sheets or trickling streams, into a reservoir or sump, which is located beneath the tower. In falling, it is cooled by the air which surrounds it. The devices for dividing the water into fine sheets, droplets or sprays, may consist of: (1) Checker work (Fig. 1); (2) corrugated surfaces; (3) troughs or baffles (Figs. 2 and 3); (4) galvanized steel wire screens or perforated trays; (5) masses of tile-tubing or galvanized iron pipes (Fig. 4) set vertically.

In every case, the tower is open at the top, and is so arranged at the bottom that atmospheric air will circulate, either by natural draft or by pressure of a fan-blower, through the descending water. The water gives up its heat to the ascending air currents by evaporation, convection and radiation.

From 75 to 85 per cent of the recooling effected in a cooling tower results from evaporation. The percentage of recooling effects by radiation, both in the tower and from the piping which conveys the water thereto, is comparatively insignificant, probably rarely exceeding more than 2 per cent.

Wood checker work, shown in Fig. 1, for cooling towers usually consists of 1 by 4-in. cypress or swamp-cedar boards set on edge and spaced about 4 in. apart.

Cooling towers may be divided into four general classes: (1) Open or atmospheric towers (Fig. 5) using natural draft. (2) Closed or chimney-flue towers (Fig. 6) using natural draft. (3) Closed or chimney-flue towers (Figs. 7 and 8) using forced draft. (4) Closed or flue towers (Fig. 8) using either forced or natural draft. The sides of open or atmospheric towers are louvered (Fig. 9) so that the air currents, which pass in through the open base, are augmented by the prevailing winds.

The closed or flue towers are completely enclosed, except at top and bottom. Openings are provided in the base for admission of the fan blast in the one case or the natural air currents in the other. Natural draft in these towers depends entirely upon the chimney action of the tower.

The choice of forced or natural draft mainly depends upon space considerations on the one hand and operating cost on the other. A forced-draft installation occupies less space than one using natural draft, but the operating expense is greater. Where cooling towers are designed for using either forced or natural draft, the forced draft may be used during the hot season and the natural draft in cool weather.

The open tower permits a somewhat greater loss of water than the closed tower. This is due to winds blowing through the louvers of the open tower. Generally, the air does not mingle so effectively with the water in open towers as it does in closed towers.

The principles involved in cooling-tower computations are similar to those pertaining to cooling ponds and spray fountains. The cooling effect depends upon the water- and air-temperatures, the relative humidity of the air, and the effectiveness of air-and-water con-

* This is the third of a series of articles the material of which constitutes a portion of the author's forthcoming book, "Steam Power Plant Auxiliaries and Accessories." It is copyrighted by the author and all rights are reserved.

tact. Towers of different types vary in the effectiveness with which the air is utilized as a cooling medium.

Computations to determine cooling-tower performance should be based on the results of tests and practice rather than on entirely theoretical assumptions. If the condition of the atmosphere as to temperature and humidity, the temperature of the water coming from the condensers, the quantity of water each unit-volume of air will absorb, and the degree of efficiency under which the tower will operate, are known, then reasonably-close approximations may be made for any specific case by applying the general methods of computation previously given for cooling ponds. The general method is illustrated in a following example.

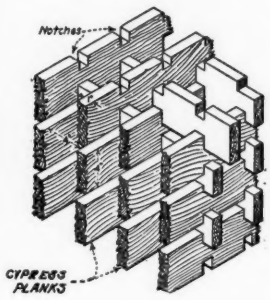


FIG. 1. CYPRESS BOARD CHECKER WORK FOR COOLING TOWERS

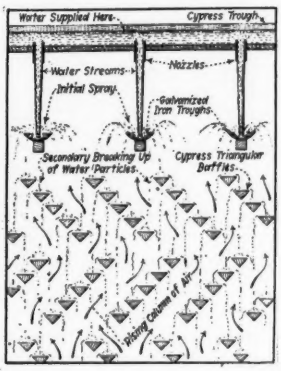


FIG. 2. TROUGHS AND BAFFLES

In the operation of a cooling tower, the same water is used over and over again. Through the process of cooling there is a certain loss which must be made up from some outside source. The water which must be supplied to compensate for this loss is known as make-up water and is equal to: (Water lost by evaporation)+(water which is splashed or blown out of the cooling tower). Assuming that there is no loss except that due to evaporation, the amount of heat taken away from the water in circulation will equal the number of pounds of water lost, multiplied by approximately 1000. In other words, every pound of water evaporated will carry away 1000 B.t.u. and cool 1000 lb. of water 1 deg. F., or 100 lb. of water 10 deg. F., etc. Therefore, to cool 100 lb. of water 10 deg. F., it requires the evaporation of 1 lb. of water, or 1 per cent of the amount cooled. Thus, theoretically, the make-up water will be 1 per cent of the water circulated, to cool the water 10 deg. Actual tests on several towers under different conditions have shown the actual loss to be less than 1½ per cent of the total amount circulated, or practically that due to evaporation.

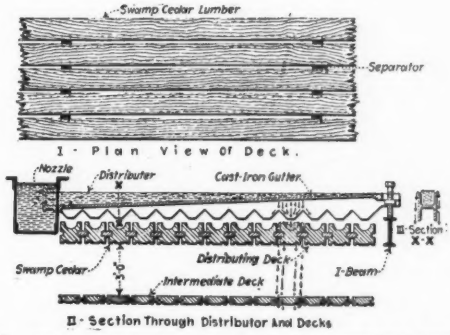


FIG. 3. DISTRIBUTOR AND DECKS OF A COOLING TOWER

Under usual ammonia-condenser conditions a cooling tower may be expected to cool the water by from 5 to 14 deg. F.; about 10 deg. F. is a reasonable expectancy. For steam condensers, a tower may be expected to decrease the temperature of the water by from 20 to 50 deg. F.

TABLE I. TABLE SHOWING TEST DATA FOR LOW-TEMPERATURE NATURAL DRAFT COOLING TOWERS WHICH ARE SUITABLE FOR AMMONIA CONDENSERS

No. of Test	Atmospheric Conditions				Cooling-Tower			Cooling	Ranges		Efficiencies			Relation of Final Temp. To Wet And Dry Bulbs	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Dry Bulb	Wet Bulb	Relative Humidity	Wind Miles Per Hr. & Direction	Initial Temperature	Final Temperature	Average Final Temperature	Perfect Range	Actual Range	Average Range	Average Efficiency	Actual Efficiency	Above Or Below Average ±	Above W-Bulb	Above Or Below D-Bulb ±
1	74°	61°	47	3-NW	73°	65°	67°	12°	8.0°	6°	50 %	66 %	+16 %	4°	-9°
2	89°	74°	48	Moderate	81°	76°	79.5°	7°	5°	1.5°	21 %	71 %	+50 %	2°	-13°
3	93.5°	77°	47	5-SW	83°	77.5°	82.6°	6°	5.5°	0.4°	6.6 %	92 %	+85.4 %	0.5°	-16°
4	70°	60°	55	0	70°	62°	65°	10°	8°	5°	50 %	80 %	+30 %	2°	-8°
5	93°	73°	35.5	5-SW	66°	75°	81°	14°	11°	5°	36 %	80 %	+44 %	3°	-13°

Note.- Attention is called to tests 2, 3 and 5, made in extremely hot weather. In test 4 there was no wind, the cooling being effected entirely by natural draft. Towers were loaded to capacity. The cooling surface in each consisted of 10 decks (Fig. 13) spaced 3 ft. apart, giving a total drop of 30 ft. to the collecting basin. Values in columns 7, 10 and 11 are the results obtained by applying For. (5) to the temperature conditions of the tower under test.

Computation of Temperature Reduction

To compute the average temperature reduction effected in summer weather by atmospheric cooling towers now in operation in this country and abroad, use the following empirical formula which is derived from the results of a large number of tests.

(5) $$T_a = (T_d + 2T_w + T_1) \div 4$$

Wherein all temperatures are in degrees F. and T_a = average temperature of the cooled water which leaves the cooling tower. T_d = dry-bulb-thermometer or air temperature. T_w = wet-bulb-thermometer temperature. T_i = temperature of water entering the cooling tower. cent. Relative humidity of air leaving the tower = 100 per cent. Temperature of water entering the tower = 108 deg. F. Temperature of water leaving the tower = 88 deg. F. Quantity of air circulated = 50,000 cu. ft. per min. Efficiency of tower = 51 per cent. These

TABLE II. TABLE SHOWING TEST DATA FOR HIGH-TEMPERATURE NATURAL DRAFT COOLING TOWERS FOR STEAM CONDENSER INSTALLATIONS

Test No.	Atmospheric Conditions				Cooling-Tower			Cooling	Ranges		Efficiencies			Relation of Final Temp. To Wet And Dry Bulbs	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Dry Bulb	Wet Bulb	Relative humidity	Wind Miles Per Hr. & Direction	Initial Temperature	Final Temperature	Average Final Temperature	Perfect Range	Actual Range	Average Range	Average Efficiency	Actual Efficiency	Above Or Below Average	Above W-Bulb	Above Or Below D-Bulb
1	92°	77°	50	4-SW	108°	81°	88.5°	31°	27°	19.5°	62.9 %	87.1 %	+24.2 %	4°	-11°
2	90°	79°	61	5-S	114°	85°	90.5°	35°	31°	23.5°	67.1 %	88.6 %	+21.5 %	4°	- 7°
3	71°	69°	90	0	116°	75°	79.0°	37°	31°	27.0°	73.0 %	83.8 %	+10.8 %	6°	+4°
4	69°	65°	81		113°	76°	78.0°	47°	36°	34.0°	72.3 %	76.6 %	+ 4.3 %	11°	+7°
5	76°	70°	74	Light	120°	78°	84.0°	50°	42°	36.0°	72.0 %	84.0 %	+12.0 %	8°	+2°
6	86°	65°	51	Good	125°	76°	85.0°	60°	49°	40.0°	66.0 %	81.6 %	+15.6 %	11°	-10°
7	79°	68°	57	Fair	124°	78°	85.0°	56°	46°	39.0°	70.0 %	82.1 %	+12.1 %	10°	- 1°

Note.--These towers are capable of decreasing the temperature by from 25 deg. fahr. to 50 deg. fahr., and are suitable for gas-engine and steam-condenser work. Attention is called to test 3, without wind, the temperature was decreased by 31 deg. fahr. and the final temperature approached to within 6 deg. fahr. of the wet-bulb. Other conditions same as specified for preceding table.

Tables I and II show average values computed with the preceding formula.

Cooling towers can be designed which will reduce the cooled-water temperature by from 10 to 50 per cent below that given by the preceding formula. The possible maximum temperature reduction is determined by the cooling range and by atmospheric conditions.

Typical data pertaining to cooling-tower performance have been obtained from a series of tests made

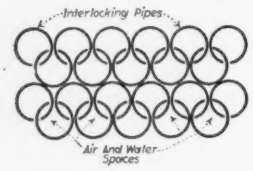


FIG. 4

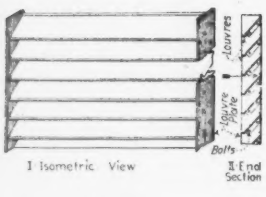


FIG. 9

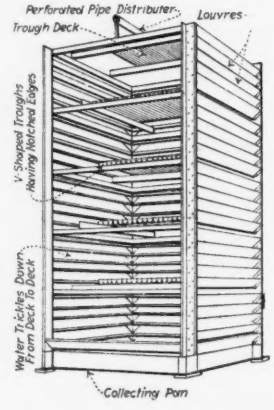


FIG. 5

FIG. 4. INTERLOCKING PIPE FILLING FOR MIXING CHAMBER OF COOLING TOWER

FIG. 5. OPEN COOLING TOWER USING NATURAL DRAFT

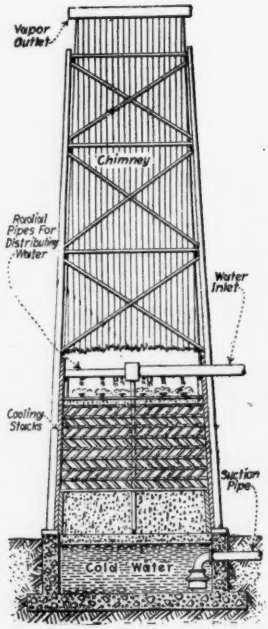
FIG. 9. SHEET-METAL COOLING TOWER LOUVERS

with closed cooling towers using forced draft. They are as follows.

Quantity of water circulated = 640 gal. per min. Temperature of air entering the tower = 70 deg. F. Temperature of air leaving the tower = 94 deg. F. Relative humidity of air entering the tower = 50 per

data represent about average practice for the given type of installation.

Using the above data, and allowing 8.3 lb. to the gallon, the heat added to the water while passing through the condenser = 640 × 8.3 × (108—88) =



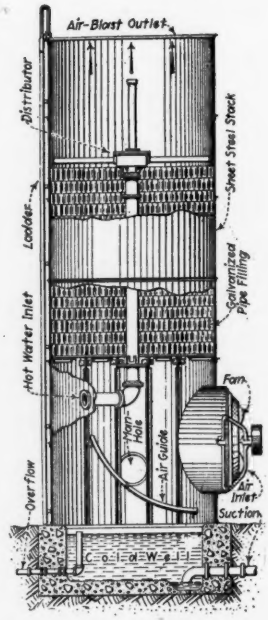


FIG. 6. CLOSED COOLING TOWER USING NATURAL DRAFT

FIG. 7. CLOSED TOWER USING FORCED DRAFT

106,240 B.t.u. per min. Assuming the specific heat of air to be 0.019 B.t.u. per cu. ft., the heat which the air absorbs, by convection and radiation, from the water in the tower = 50,000 × 0.019 × (94 — 70) = 22,800 B.t.u. per min. = 22,800 ÷ 106,240 × 100 = 21.46 per

cent of the heat which the water absorbed in the condenser. Hence, the heat which the water gives off by evaporation = 106,240 — 22,800 = 83,440 B.t.u. per min. = (83,440 ÷ 106,240) × 100 = 78.54 per cent of the heat which the water absorbed in the condenser. Assuming that each pound of the evaporation abstracts 1000 B.t.u., the water-loss = 83,440 ÷ 1000 = 83.44 lb. per min. = 83.44 ÷ (640 × 8.3) 100 = 1.57 per cent. Wind losses might increase this to over 2 per cent. In practice, the usual water loss may be from 2 to 3 per cent.

The per cent of water-loss from cooling towers, as noted above, is less than the lowest per cent of loss that can be obtained with spray fountains. This is an important item in favor of the cooling tower.

Computing Proportions of a Cooling Tower

A method of computing the proportions of a cooling tower will be explained by the use of an illustrative example. Cooling-tower design is, because of the necessity of using results from existing installations as precedents, properly a function of men of considerable experience in this particular branch of engineering.

A forced-draft cooling tower is required to recool 1,000,000 lb. of condensing water per hour through 25 deg. F. The circulating air is assumed to be at a temperature of 75 deg. F. when it enters the tower and at

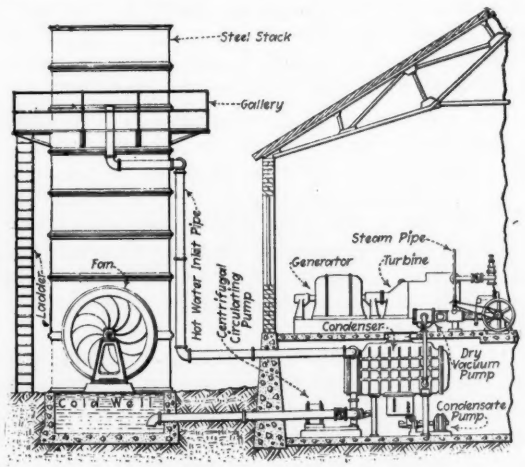


FIG. 8. CLOSED TOWER USING FORCED DRAFT INSTALLED WITH SURFACE CONDENSER

105 deg. F. when it leaves. What should be: (1) The total horizontal cross-sectional area? (2) The total horizontal length of each side? (3) The total height of the checkerwork?

Solution.—It may be assumed that the tower is to be furnished with a cypress-board checkerwork for dividing the descending water into a multitude of thin sheets. Practice has shown that air velocities, in cooling towers, of about 700 ft. per min. produce the best results. It may be assumed that the evaporating or cooling surface afforded by the cypress boards is about 8 sq. ft. per cu. ft. of space occupied by the checkerwork. It may further be assumed that about 64 per cent of the total horizontal cross-sectional area of the checkerwork is effective area, or free area. Also that 20 B.t.u. per hour, per degree of cooling, will be abstracted from the condensing water for each square foot of evaporating surface.

The water will absorb, in the condenser, approximately 1 B.t.u. per lb. for each deg. F. of temperature increase. Hence, the total quantity of heat to be abstracted in the cooling tower = 25 × 1,000,000 = 25,000,000 B.t.u. per hr. The quantity of heat abstracted per square foot of cypress-board evaporating surface = 20 × 25 = 500 B.t.u. per hr. Therefore, the requisite total area of evaporating surface = 25,000,000 ÷ 500 = 50,000 sq. ft. Hence, the total volume of space to be occupied by the checkerwork = 50,000 ÷ 8 = 6250 cu. ft.

TABLE III. TABLE OF RELATED DATA PERTAINING TO FORCED DRAFT COOLING TOWERS FOR USE WITH CONDENSERS OF COMPOUND CONDENSING ENGINES

Capacity Of Condenser, In Horse Power	Height Of Cooling-Tower In Feet	Dimensions Of Cooling-Tower At Base, In Feet.	Number And Size, In Feet, Of Fans	Speed Of Fans, In Revolutions Per Min.	Power Required For Fans, In Horse Power
50	25	19 x 19.5	1 - 6	110	1.35
75	25	19.8 x 20.0	1 - 6	160	1.75
100	25	20.0 x 20.8	1 - 7	145	2.25
150	25	21.5 x 22.5	1 - 8	145	3.50
200	25	23.3 x 24.5	1 - 9	135	5.50
250	26	24.5 x 25.3	1 - 10	135	8.00
300	26	26.5 x 27.0	1 - 10	145	11.00
400	27.5	27.5 x 24.5	1 - 12	115	14.00
500	27.5	29 x 30	1 - 12	145	18.00

Assuming that about 21.5 per cent = 0.215 of the heat in the condensing water passes to the air by convection and radiation, the total quantity of heat so removed = 25,000,000 × 0.215 = 5,375,000 B.t.u. per hr. Therefore, assuming the specific heat of air to be 0.019 B.t.u. per cu. ft., the requisite quantity of air, of the given entering and leaving temperature = 5,375,000 ÷ [0.019 × (105 — 75)] = 9,429,824 cu. ft. per hr. = 9,429,824 ÷ 60 = 157,167 cu. ft. per min.

For an air velocity of 700 ft. per min., the requisite effective cross-sectional area of the checkerwork = 157,167 ÷ 700 = 224.5 sq. ft. This being about 64 per cent = 0.64 of the total cross-section area, the requisite total area = 224.5 ÷ 0.64 = 351 sq. ft. Hence, the length of each side of the square base of the checkerwork = $\sqrt{351}$ = 18.7 ft., or, approximately, 18 ft. 8.5 in. The requisite height for the checkerwork, then, = 6250 ÷ 351 = 17.8 ft., or, approximately, 17 ft. 9.5 in.

The total height of a cooling tower of the type specified above, would be given by the sum of the fan-height + the height of the checkerwork + about 2 ft. for the height of a distributing trough (Fig. 3) + about 4 ft. for the depth of the sump or well. If the tower is erected at the ground level, the sump may be sunk below the surface of the ground.

The height of the fan blower required for a cooling tower may be obtained from manufacturers' tables of the dimensions and capacities of such blowers. Typical related data pertaining to fan-draft towers, for use in connection with condensing-engine plants, are given in Table III.

The cost of a cooling tower, erected in place, may be from $6 to $7 per kilowatt of the power developed by the plant. Or, otherwise, from $4.50 to $5.50 per horsepower of the engines to be served. These values are based on the assumption of a 26-in. vacuum in condenser operation.

Turbine Operation for the Average Plant

PARTS THAT REQUIRE CAREFUL INSPECTION AND GENERAL ROUTINE INSTRUCTIONS. BY W. A. DARTER

A TURBINE-GENERATOR set requires so little attention when comparing its operation with other types of units that the average engineer will neglect to give a turbine even the small amount of attention required. The tendency of the operator is to let it run too long for safety because of its simplicity.

Assuming that a turbo-generator is in good condition, one of the most important things in its operation is its lubrication. In the reaction type, the wear in the bearings must be kept down to a minimum and with the high speed of the shaft proper lubrication becomes a necessity. As long as the two bearing surfaces are separated by an oil film there can be practically no wearing of the bearings. Because a high-speed bearing runs at a high temperature does not necessarily mean that the bearing metals are coming in contact with each other. The friction of a lubricated bearing is due to the shearing of the lubricant itself and this shearing of the oil produces heat which does not harm the bearing. The natural assumption is, therefore, that the less the oil friction is, the more efficient the lubricant becomes, so long as the lubricant keeps the bearing metals apart.

Lubricating oil for use in turbine bearings which are water-cooled, must not show any signs of emulsification. The emulsification of the oil will eventually choke up the oil ducts and screens, and will give serious trouble.

Dirty oil cannot be used because of the clogging of screens and pipes; if the oil is heavy it will carry this dirt in suspension and cause rapid wearing of the bearings. Too light an oil with low viscosity cannot be used because of the shearing friction of the oil in the bearings; as this oil becomes heated, the viscosity decreases and naturally the bearing will run hot, due to the excessive speed of the turbine rotor.

Too heavy an oil will not separate from water and dirt readily and will emulsify quicker than lighter oils and carry dirt in suspension. A compromise as regards viscosity must be made when selecting turbine oils. The ideal turbine oil is one that will separate from water and foreign matter rapidly, one that will retain its viscosity under continuous heat and use, and one that can be easily filtered. It is always wise to leave the lubricating problems of a high-speed turbine to a lubricating engineer.

The working temperature of a high-speed bearing will naturally be high, some running as high as 200 deg. F. or more. The temperature of the bearing, nevertheless, must not reach the point where the viscosity of the oil will break down and fail to keep the bearing metals separated. The cooler the bearings can be kept, the longer will the life of the oil be. The general opinion gives about 125 deg. F. as the best temperature for the oil leaving the bearing. Some engineers favor a high temperature bearing because the oil friction is less, due to the lower viscosity of the hot oil.

Correct oil pressure should be maintained at all times on the bearing while the turbine is in operation. If this oil pressure varies, there is a reason; and this reason should be determined. An increase in the oil pressure indicates that the oil ducts are probably clogging up, or the screen needs cleaning. When the oil pressure becomes low, there may be insufficient oil or it may be due to a leaky oil pump or oil ducts.

A record of bearing temperatures should be kept, in order to compare temperatures from day to day or month to month. This record will enable one to know the character of the operation of the bearings. A steady rise in bearing temperatures may indicate bearing trouble, or an insufficient supply of oil, or the breaking down of the lubricant. The changing temperature of the cooling water will also indicate the changing temperature of the bearing. With this temperature record of the oil, a sample of the lubricating oil should be taken at intervals in order to compare them and determine the characteristics of the lubricant.

Cooling of the bearings by water and of the generator by air are also important factors in the operation of a turbine. The water-cooling coils must be kept free from scale and free from leaks. All dirt should be screened out before the water enters the coils. The cooling air should contain as little dust and lime as possible. The entrance of the cooling air should not be near any cotton gin, or mill, where the air is full of lint and dust. If the air is water cleaned, it should also be free from excessive moisture when it enters the generator.

The temperature of the bearings can be determined by taking the temperature of the lubricating oil. The temperature of the electrical windings cannot be taken so easily. The most practical safe way to check the temperatures rise in the rotor winding and stator winding is to check the resistances of the two coils when they are cold and hot. About 10 per cent C. should be added to the calculated temperature to arrive at a correct temperature of the coils.

It is important upon starting up a turbine to know that the rotor is in its proper position. There must be enough clearance on each side of the blade to allow for expansion and the floating of the rotor. To set the rotor, force it carefully toward one end until a very slight rubbing is noticed on the wheels and mark this position, then back off in the other direction carefully until a slight rub is noticed in this direction, and then set the rotor halfway between the two rubbing points. Rubbing between parts will quickly heat up the wheels and cause stripping of blades.

The governor should be inspected oftener than other parts of the turbine and should be kept working free and steady. It is important to keep the governor rod well packed and lubricated to insure quick action in case the load is suddenly thrown on the turbine. All packing should be tested before the turbine is put into service. If the governor valves become worn and admit too much steam on no load, this steam will cause the turbine to overspeed and probably trip. The setting and adjustment of the governor valve should be left to an experienced man.

The safety stop should act at a certain definite speed; usually about 10 per cent above normal speed, and when

this safety stop acts it should close the throttle completely and cut off the supply of steam quickly. To make sure that the safety device will act at the right speed, make the hydraulic governor inoperative and bring the turbine speed gradually up to the tripping out point. If the turbine does not trip out at the required point, reset the tripping device by loosening up the tension on the springs and try again until the required tripping point is reached. To test out the emergency stop, always trip the safety device every time the turbine is stopped.

In making an over-speed test, a strain is put upon the turbine; to overcome this excess strain, some companies use a counter-weight which is furnished by the manufacturers, which makes the turbine trip out at a certain per cent of the normal load.

The vacuum breaker is also an important part of the turbine, and it is the part most often neglected. Its purpose is to cut off the water supply in case the water begins to back up in the turbine wheels. The vacuum breaker must operate without failure in case the jet condenser fails to operate. Serious accidents may happen if water backs into the turbine. The vacuum breaker should be tested while the turbine is standing still.

The condenser should be inspected for air leaks and scale formation if the water contains solid matter. The rod packing should be pliable and the water-seal tubes open. If the jet condenser is motor driven, care should be taken to protect this motor from water.

The relief valve on the exhaust line must be free to work and trip at the required pressure. The water seal should make it airtight. There should never be a valve or any other device that might prevent the exhaust steam from leaving the turbine in case the vacuum broke. Good steam traps are necessary to carry away all condensations, and the exhaust piping of the turbine should not be so constructed that the last stages of the turbine will run in water. The loss of power and damage due to wear is great under such conditions.

Starting Up the Turbine

Large turbines should be thoroughly warmed up before they are put into operation and they should be started non-condensing or with a very low vacuum. Enough steam should be admitted to clear the turbine of water or condensate, and just enough more to turn the rotor over slowly. This rotation of the rotor enables it to warm up thoroughly all over. If only a part of the rotor comes in contact with the steam, this part becomes heated and results in distortion and strains.

Small turbines require very little warming up. It is, nevertheless, good practice to warm up all turbines before they are put into service. When the throttle valve is open wide enough to start the turbine, it should then be closed and immediately reopened enough to keep the rotor turning slowly.

After the turbine has been warmed up and a vacuum produced on it, the throttle valve should then be opened slowly until the rotor reaches its critical speed where it gives its maximum vibration. At this point, the throttle should be opened much quicker in order that this point of maximum vibration can be passed over quickly. After the critical point has been passed, the speed should then be accelerated slowly until the governor takes up the control of the steam entering the turbine. Drain pipes should remain open until the turbine has reached its full speed.

Collector Rings

The generator collector rings should be kept true and the tension on the slip ring brushes should not be so great that it will cause excessive wearing of the carbon brushes. If the exciting current tends to pit the collector rings and cause excessive wearing of the brushes and slip ring, the manufacturers should be consulted.

The synchronizing switches and motor control of the turbine speed must be kept in good order. The speed regulator plug or switch should open automatically when released by the operator.

Putting Turbine on Board

After the turbine has been synchronized with the other units in operation, the load should be thrown on the turbine gradually. This method keeps down excessive strains and, probably, temporary vibrations.

The kw. load to be taken by a turbine depends upon the power factor of the load. Some operators watch the kw. meter, and as long as it does not read above the kv.a. rating of the generator, they feel safe, even though the power factor of the load may be around .75.

It is important not to overload a generator, and to watch the kv.a. load carefully, for statistics show that over 35 per cent of generator troubles come from overheating of the stator and rotor windings. With low power factor and full kw. load, the rotor fields require a great deal of over excitation, and this extra exciting current causes the greatest percentage of breakdowns.

When a turbine is used for standby operation, it is necessary to supply enough steam to keep the blade temperature down. If practically no steam is admitted to the turbine while it floats on the line, the blades will churn the air and produce friction. The safe method would be to let the turbine take enough steam to pull a small fraction of its capacity.

Running the turbine with the highest efficiency should be the highest ambition of the operating engineer.

The vacuum of the condenser should be watched closely. There is a loss in fuel of about 6 per cent for every inch of vacuum between 26 in. and 29 in. All air leaks should be located and stopped. If the turbine works against back pressure, this back pressure should be watched and kept at a minimum. The loss in fuel is about 2 per cent for every pound of back pressure on the turbine.

Superheated steam should be used when it is available. Wet steam will wear away the blades much faster than dry or superheated steam. All steam lines to the turbine should be well drained of all condensates. Sometimes a part of the hot condenser water can be sent to the feed-water heater and some heat reclaimed.

Follow the instructions of the manufacturers implicitly. Turbine operation is a specialized branch of engineering and a considerable amount of study of the subject is necessary before innovations of any kind can be adapted with prospects of success. Make no changes without first consulting with the manufacturers as to the feasibility of such changes.

Steam Jet Coal Conveyor

Emergency Method of Storing Coal Proves Practicable

MANY engineers are familiar with steam jet conveyors, but their experience with this method of conveying bulk materials has been limited to ash handling in most cases.

During the recent world war it was necessary for most plants to provide facilities for storing and handling large quantities of coal. Many plants which had never before stored coal were forced to provide storage space and means of handling these large quantities of coal to insure against shut-downs. The method of handling this coal was quite a problem and various methods were used, some being expensive, others inexpensive. Then it was a case of getting equipment to handle this coal and getting it in a hurry.

John Stophilbeen, chief engineer for the Waldorf Paper Products Co., of St. Paul, Minn., was one of the engineers who was forced to provide means for handling storage coal. Until 1917, they stored very little coal, being able to get it as required, and as they expected conditions to get back to normal within a few years, they did not like to invest in expensive machinery for handling coal during the emergency. A storage space with trackage just across the street from the power plant was provided and the piling problem was solved by Mr. Stophilbeen by constructing a steam jet coal conveyor.

The steam jet coal conveyor was made of 7-in. wrought iron pipe and fittings. Figure 1 shows one of the conveyors set up ready for duty. The material necessary for this conveyor was two lengths of 7-in. wrought iron pipe, one coupling, one 45 deg. elbow, one plug for 7-in. tee, one short piece ½-in. pipe used as a nozzle. Figure 2 shows the detail of the intake end of the conveyor. One end of the tee was plugged, this plug being drilled and tapped in the center for the standard ½-in. pipe nozzle. The discharge end of the nozzle was reamed out as much as possible to conform to the design of steam jet nozzles as applied to ash conveying systems. A steam line of 1¼-in. standard pipe was run to the conveyor, a blowoff being provided at the conveyor to clear the line of water when starting up.

There were two unloading points at the storage space and therefore two such conveyors were made. Coal cars were spotted at these points and a tapered wood chute placed between the car and the coal intake of the conveyor. At first some difficulty was experienced due to plugging up of the conveyor. This was due to the fact that no separate air intake was provided. A sheet metal pipe was obtained and fastened to the coal intake. While this reduced the size of the coal intake, this pipe was flattened as much as possible. This sheet metal pipe was for the purpose of providing air and there was no further trouble with plugging of the conveyor. A 45-deg. elbow was placed at the discharge end of the conveyor and in this manner it was possible to get quite a piling range.

Figure 3 shows part of the coal pile. With this conveyor, one man could unload and pile a 50-ton car in 10 hr., the conveyor having adequate capacity to handle the coal as fast as a man could shovel it. Mr. Stophilbeen estimates that these conveyors have handled 7000 tons of Illinois screenings in 4 yr. The conveyors are still in good condition with the exception of the first length of conveyor pipe. This has worn through on both conveyors.

While a number of improvements can no doubt be made on these conveyors they have served their purpose well and unless there is another serious coal shortage they will not be used again. I believe that these conveyors demonstrate the practicability of the steam jet conveyor for handling coal as well as ashes.

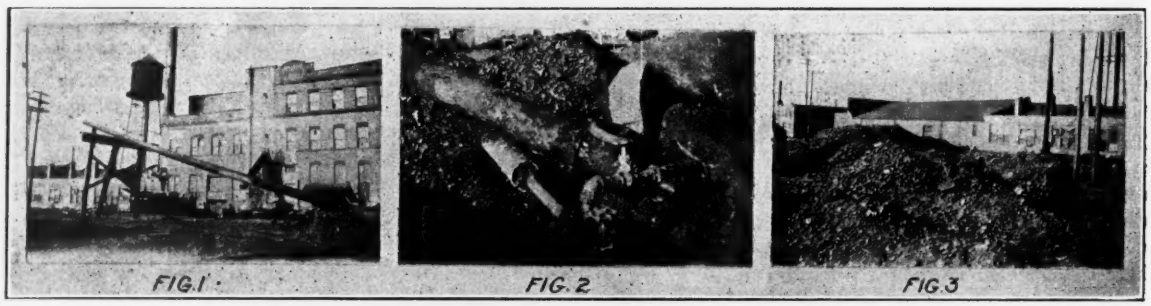


FIG. 1. STEAM JET CONVEYOR IN POSITION FOR STORING COAL. FIG. 2. INTAKE END OF CONVEYOR. FIG. 3. COAL PILED WITH STEAM JET

U. S. Civil Service Commission announces an examination, receipt of application to close May 17, for mechanical engineer to fill a vacancy in the Bureau of Entomology, Department of Agriculture, for duty at Tallulah, La., at $3000 a year, and vacancies in positions requiring similar qualifications, at this or higher or lower salaries. Duties will be to perform mechanical engineering work connected with the designing, development and construction of suitable dusting machinery for the poisoning of the cotton-boll weevil; to design such machines, supervise the construction of models and their testing and modification; to prepare working drawings; to carry out all lines of machine-shop administration, including the layout of work; and to perform other related duties. Competitors will be rated on education and preliminary experience, responsible experience and fitness, and must not have reached their fiftieth birthday on the date of examination. This age limit does not apply to persons entitled to preference because of military or naval service. Apply for Form 1312, stating examination title.

Uniform Coal Contract Proposed

FOR some time past the Fuel Committee of the National Association of Purchasing Agents has been engaged in formulating recommendations for reasonably uniform provisions in coal contracts. The purpose of the committee has been to express its idea of a fair contract to be used for the purchase and sale of coal. To avoid overlooking important details and to prevent any bias in its suggestions, the committee conferred with a number of leading producers and wholesalers in the coal field, holding a meeting for this purpose at the Hotel Pennsylvania, New York, on March 15.

The conclusions of the committee are expressed in the provisions given herewith. It is believed that the form can be advantageously used for most commercial contracts for the purchase of coal, and where special conditions require special clauses these might be added to the contract.

The form has been prepared simply as a convenience to the members of the National Association of Purchasing Agents and the trade, and is submitted by the committee for the use of those whose requirements it will meet. It has been carefully worked out to cover all general conditions and is particularly designed to prevent misunderstandings between buyer and seller such as arose from the loosely-drawn agreements in effect last year.

The administrative council of the Fuel Committee of the National Association of Purchasing Agents is as follows: Chairman, E. H. Hawkins, of E. I. du Pont de Nemours & Co., Wilmington, Del.; H. M. Mitchell, of Rome Mfg. Co., Rome, N. Y.; J. E. Stauffer, of A. M. Byers Co., Pittsburgh, Pa.; R. M. Sedgwick, of Standard Chemical Co., Toronto, Ont.; H. M. Cosgrove, of J. H. Markham, Jr., Tulsa, Okla.; H. L. Ogden, of Gas & Electric Improvement Co., Boston, Mass.

In the preparation of the proposed contract form the committee has had the guidance and advice of W. B. Symmes, Jr., of New York, formerly solicitor for the United States Fuel Administration.

This is contract form for coal recommended by the National Association of Purchasing Agents:

AGREEMENT entered into this .... day of ...., 19.., between ..... of ....., hereinafter referred to as Seller, and ..... of ....., hereinafter referred to as Buyer.

The Seller hereby agrees to sell and deliver and the Buyer hereby agrees to purchase between the .... day of ...., 19.., and the .. ..day of ....., 19.., the quantity and kind of coal and at the price hereinafter stated upon the terms and conditions herein contained, to wit:

QUANTITY ..... net tons

RATE OF SHIPMENT (approximately) ..... net tons per month.

DESCRIPTION

Approximate Analysis

PRICE $..... per net ton of 2000 lb. f.o.b. cars mines.

POINT OF DELIVERY: f.o.b. cars mines.

TO BE SHIPPED TO.....

DESTINATION .....

ROUTING .....

KIND OF CARS PREFERRED.....

TERMS AND CONDITIONS

1. Invoices shall be paid on or before the.....day of each month for all coal shipped during the preceding calendar month. Non-compliance with said terms of payment shall give the Seller the right to suspend further shipments until all previous shipments are paid for, and if in the judgment of the Seller the financial responsibility of the Buyer shall at any time become impaired and written notice thereof be given by the Seller to the Buyer, the Seller shall have the right to suspend further shipments until adequate security for payment hereunder is furnished by the Buyer. If such security is not furnished within thirty days from such notice, the Seller shall have the right to cancel this agreement.

2. All settlements shall be governed by the actual railroad weights ascertained at the usual points at which railroad shipments from the mine or mines producing the coal shipped hereunder are weighed.

3. Strikes, fires or accidents at the mine or mines where the coal sold hereunder is produced, embargoes, shortage of car supply or other similar occurrences beyond the control of the operator of such mine or mines which prevent or interrupt the shipment of such coal, shall excuse Seller's failure to ship hereunder during the continuance of such occurrence, provided

(a) the Seller is the owner or exclusive sales agent of the mine or mines at which the coal sold hereunder is produced, or prior to or simultaneously with the execution of this agreement has entered into a written contract for the purchase of a sufficient quantity of coal from such mine or mines to fulfill the obligations of the Seller under this agreement;

(b) the name of the owners and location of such mine or mines is stated in this agreement;

(c) the Seller gives the Buyer written notice within five days after such occurrence of the exact nature, extent and probable duration thereof with sufficient detail to enable the Buyer to verify the same;

(d) the total available tonnage of said mine or mines during prevention or interruption of shipments as aforesaid is applied pro rata on all contracts then in force or any renewals thereof for the output of such mine or mines exclusive of contracts or sales made after such occurrence;

(e) shortage of car supply shall not excuse failure to ship hereunder if at the time of such failure there are in force contracts for the sale of more than the rated output of such mine or mines based on the car rating given such mine or mines at the date of this agreement by the railroads on which the same are located.

4. In case of strikes, fires, accidents or causes beyond the control of the Buyer which wholly or partially stop the works of the Buyer, shipments contracted for shall be suspended or partially suspended as the case may require, upon written or telegraphic notice to the Seller.

5. If the Seller shall fail to ship or the Buyer shall fail to accept the monthly shipments herein provided for and shall be excused for such failure under Articles "3" and "4" hereof, the other pary at any time after the expiration of the first three months of the contract period may, by written notice to the party who has so failed to ship or accept, reduce the monthly tonnage thereafter to be shipped and accepted hereunder to an amount equal to the average of the monthly shipments for the three months preceding such notice.

6. The purchase price of the coal specified herein is based upon present agreements with mine employes as to wages, and any increase or decrease in the cost of production of the coal shipped hereunder caused by changes in such wage agreements or by the imposition by State or Federal Statute of a direct tax on coal or the mining thereof or subsequent changes in the rate of such tax shall correspondingly increase or decrease said price of coal on any tonnage thereafter shipped hereunder and affected thereby.

7. The coal covered by this section is to be used only in the plant or plants of the Buyer and is not to be sold or diverted by the Buyer to other purposes without the consent of the Seller.

8. Waiver by either party of any default by the other hereunder shall not be deemed a waiver by such party of any default by the other which may thereafter occur.

9. Notice sent by telegram or registered mail, addressed to the party to whom such notice is given, at the address of such party stated in this agreement, shall be deemed sufficient written notice in any case arising under this agreement.

10. No understandings, agreements or trade customs not expressly stated herein shall be binding on the parties in the interpretation or fulfillment hereof unless such understandings, agreements or trade customs are reduced to writing and signed by the respective parties.

IN WITNESS WHEREOF, the parties hereto have caused this agreement to be executed in duplicate by their re-

spective officers duly authorized the day and year first above written.

.....Seller

By.....

.....Buyer

By.....

While this contract form covers the legal requirements, it leaves to be filled in the description of the coal which would include the size, preparation if any, mine or mines from which coal is taken and other data of importance to the buyer not contained in the approximate analysis which follows. Nothing is mentioned about the heat value nor the penalties nor premiums for coal of lower or higher heat value, so that those wishing to purchase coal on the B.t.u. basis must draw up additional terms as indicated in paragraph 10.

Lubrication of Diesel and Semi-Diesel Engines*

A Discussion of Lubricating Problems Encountered in Design and Operation of Diesel Engines. By Edmund G. Warne

LUBRICATION PROBLEMS have played a part of no mean importance in connection with the successful development of both Diesel and semi-Diesel (or hot bulb) machinery. Perhaps with regard to the former type the solution has been comparatively easy on account of the straightforward method in which it is possible to deal with the question of an efficient supply of oil to bearings; however, as concerns the semi-Diesel engine, a set of conditions may be encountered which demand the application of special measures.

No matter what the particular means of lubrication employed, there is not much doubt that the engineer who, in the course of practical running of machinery, makes it his business thoroughly to investigate the lubricating arrangements fitted to his plant, is unlikely to experience trouble. The actual cycle of operations in an engine depends more on the machinery than on the engineer, whereas the lubrication of bearings (although in many cases automatic) calls for a certain amount of special attention.

These considerations of investigation and attention apply especially to the average two-cycle, crankcase-compression semi-Diesel engine. It is not one of the best features of this type of plant that in most instances an ample supply of lubricating oil under pressure is practically out of the question. We find the oil delivery almost cut to minimum, whereas the natural desire of anyone who has experienced the invaluable benefits of forced lubrication is to increase the supply to a maximum. Regrettably enough, this is difficult to achieve, on account of the system of crankcase compression—a system which is widely used. The air carries practically all the "free" oil in the crank chamber to the combustion space, where the inevitable happens. In fact, if oil is present in anything like an excessive amount the engine will "run away" on it, probably with unlooked for results. This, of course, is an exceptional occurrence, and it may be mentioned that the most successful way of stopping the machinery under these conditions is by holding open the crankcase air valves.

In the case of the usual type of semi-Diesel engine, a compromise has to be effected. Generous oiling is to be avoided, while restriction of supply beyond a reasonable limit is followed by serious wear of the bearings, if not actual breakdown. As a means of relieving the situation, the plan of isolating main bearings from the crankcase is one to be commended, suitable baffles being provided for the two-fold purpose of preventing escape of air from the crank chamber during the discharge stroke, while in addition, avoiding ingress of lubricating oil from the main bearings, along the short length of shaft between.

At least one type of semi-Diesel engine is to be found which has, I believe, proved its worth, and arranged on the open crank system. It conforms to steam practice in some respects, inasmuch as crossheads and guides are fitted, while more important bearings may be seen, and—what is more important—felt. In the case referred to, a drip-feed system of lubrication is fitted, and the quantity of oil supplied to the main bearings, crankheads and crossheads, needs no special consideration beyond such attention as would be given to the average steam engine. The system might be carried out to a more advanced degree, and a direct pressure-fed oil supply introduced, closing in the lower part of the machinery to an extent which would prevent the splashing of oil, while at the same time draining off the surplus to a working tank in the circuit, as is usual with most present-day Diesel machinery.

In regard to oil pressure, 10 lb. per sq. in. seems to be more or less standard, and although this practice has stood the test of time, on account of the nature of its origin—i. e., in connection with the high speed steam engine driven dynamo or similar practice—it might be advisable to lower this figure slightly, regarding 10 lb. as maximum. This because of the lower rate of speed of the Diesel plant.

The cylinder liners of both Diesel and semi-Diesel engines are generally lubricated through an encircling ring of piping provided with branches which communicate with holes in the cylinder. The oils used are of various qualities, but with a new engine a low-viscosity oil is most suitable on account of the comparatively small clearances, while as these increase a more viscous oil may be employed. A comparatively high flash-point is desirable, in order to avoid the risk of explosion in the crank case should the gas blow past the pistons and rings; but, of course, this qualification does not arise in the case of large engines fitted with crossheads, guides and isolated cylinders.

Oil Pipes and Fittings

Lubricating oil-pipes and fittings are fruitful sources of trouble unless fixed with care. When fitted up after inspection or repair, all piping, unions, connections, etc., should be blown through, or wires should

* Abstract of paper read before the Institute of Marine Engineers.

be passed through to insure freedom from foreign matter. When dismantling, if the pipes are to remain off the engine for any length of time, it is a paying proposition to bind up the male-screwed ends with twine.

Centrifugal lubricators and their connecting pipes for crank-head bearings demand special attention. Unless spigoted in such a manner that incorrect fitting is practically impossible, the banjo should be tested circumferentially and laterally by fixing a wire on the adjacent bearing or other convenient position and turning the engine a complete revolution with the turning gear, if there is any doubt about the fitting being perfectly central.

Oil pumps supplying the various bearings are usually efficient in working, but nevertheless pay for attention. The discharge is generally variable, and adjustment may be effected by altering the length of the plunger stroke. In practically every case this may be performed while the engine is running and the number of drips per minute checked through a sight feed. A great point is cleanliness in the well of the pump and oil should be strained before filling. A periodical cleanout is advisable, but on no account should the box be wiped out with waste. Swilling out with paraffin is a good plan, after which the box should be left to drain.

Care of Operating Mechanism

Operating mechanisms for pumps are often provided with adjustable ratchet-feeds from the shaft, and many cases of failure have been traced through carelessness in watching the drive, which, if the teeth or pawls become worn, may cease. Generally the pawl wears, and it may be mentioned that an engineer who recently had to deal with eleven cases of crankhead failure found that seven instances were due to this cause. The average semi-Diesel engine is not prone to break down, but it has been stated in more than one quarter that 90 per cent of failures are due to lack of attention and failure of the oil-drip. The engineer who allows himself to become lax in the matter of attention to lubricators not only gets himself a bad name, but what is considerably worse, he may also get the engine a bad name, and I am afraid that it is only too true when it is stated that the more careless the engineer is in regard to lubrication the more thorough is his abuse of the engine when a breakdown occurs.

Water pump eccentric straps often come in for more than their share of neglect, especially when grease lubricators are fitted. A grease lubricator has a comfortable look about it; one hopes it contains grease, but the lubricating properties of hope are not pronounced. I do not think I am alone in advocating that a worsted-feed oiler on pump straps is a better fitting; the oilcup and needle-valve arrangement is also fairly reliable, but it has the disadvantage of being affected by vibration, and may even close off entirely if insecurely locked.

In conclusion, I would like to lay stress on cleanliness. Dirt is the doom of efficient running. The crank chamber must be clean and above all free from particles of waste, while the same remarks apply to oil-boxes. The presence of water is naturally to be avoided, perhaps specially with regard to worsted-feed containers, where its presence is often unsuspected for considerable periods.

Powdered Graphitic Coals

OF ESPECIAL value and timeliness was a paper read recently before the Providence Engineering Society on the "Development in Powdered Coal Burning" by H. D. Savage of the Combustion Engineering Corporation, who based much of his discussion on Rhode Island graphitic anthracite coal, using it as an instance of an inferior fuel that was being made of large commercial value through the pulverizing process.

After a brief review of some of the history of pulverized fuel, Mr. Savage in his paper takes up the Rhode Island deposit in showing where pulverization solves a difficult question.

The paper says in part:

"In the coal reserves of the United States the supply of Rhode Island graphitic anthracite is estimated at about 1,000,000,000 t. Think of the enormous economic possibilities presented by the development of this deposit as a substitute for the very costly imported product—an accomplishment by no means impossible of achievement.

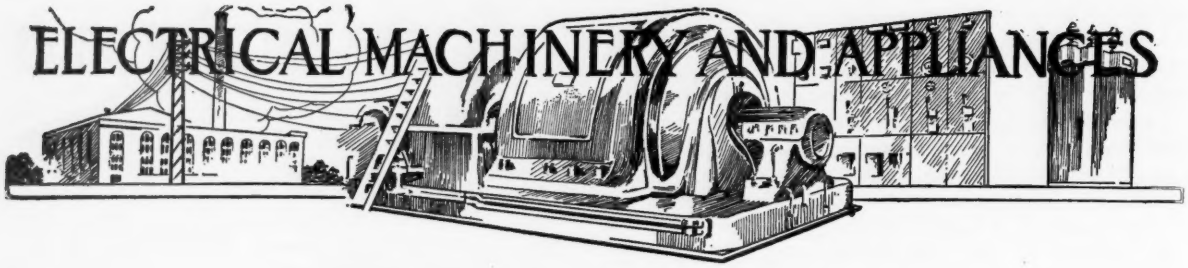
"The Geological Survey, however, has not in the past taken a very optimistic view of this possibility. To quote from Professional Paper No. 100-A:

" 'The Rhode Island anthracite region, although known since 1760, is of little economic importance, for the coal has never been mined for a long period on a commercial scale, and, judging from its composition and the metamorphism of the surrounding rocks, it seems doubtful whether it will ever have more than a local value, if it is worked at all.'

"Assuming, however, that modern methods of mining have made the recovery of this coal possible on a commercial basis, there would seem to be no further obstacle to its use as an industrial fuel of merit.

"The inferiority of Rhode Island graphitic anthracite as compared with Pennsylvania anthracite when burned by the ordinary methods is due to its physical structure and the nature of the ash content. The only difficulty met in burning this graphitic coal in ordinary methods is that the ash will not free itself as combustion progresses. The coal makes a very brilliant fire for a short space of time, but the lump soon becomes surrounded with ash and is snuffed out. When burned in suspension in pulverized form combustion is, of course, instantaneous, and this trouble does not exist. The elimination of this one difficulty, therefore, makes it a thoroughly reliable and usable fuel. This assertion is based on very meager information, to be sure, as the only test which we ran on this coal covered a period of only 4 hr. and some 4 t. of coal. This test, however, clearly indicated that in a correctly designed plant there would be no difficulties encountered when burning this fuel in pulverized form. There was no attempt made to run a boiler test, but simply to establish for our own satisfaction the fact that this fuel was of value, and that it could be burned under proper conditions.

"The best results in burning anthracite of any kind are obtained when a constant rating can be maintained, as a high temperature in the surrounding refractories is a factor in securing desired results. It will not be found a satisfactory fuel for low ratings, or where the boilers are banked any considerable length of time, except in special cases, where the plant is designed for that particular service."



Alternating Current Meters

FREQUENCY METERS, SYNCHRONOSCOPES AND POWER FACTOR INDICATORS; THEIR THEORY OF OPERATION, CONSTRUCTION, INSTALLATION AND CARE. BY VICTOR H. TODD

ON DIRECT current only two instruments, the ammeter and the voltmeter, are required to indicate the correct functioning of the electric system. Even a wattmeter is not absolutely necessary, as from the volt and ampere readings the watts can be easily calculated. But on alternating current there are several additional effects which should be known to secure correct operation and in order to determine these new quantities, additional instruments are required. For instance, the

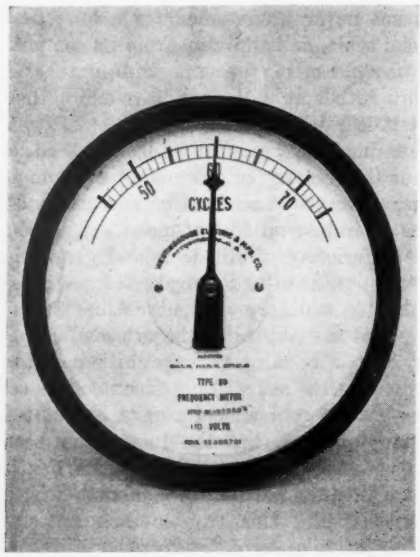


FIG. 1. A TYPICAL FREQUENCY METER

speed of induction and synchronous motors depends on the speed of the generator or rather the "frequency" of the alternating-current supply. This frequency is often expressed as "cycles per second" or "alternations per minute." To measure the frequency at any point on the system requires an accurate frequency meter.

In Fig. 1 is illustrated a true electric frequency meter and in Fig. 2 the same meter with the dial removed, exposing the interior mechanism. As shown in the diagrammatic scheme of parts, Fig. 3, there is an aluminum disk A, pivoted on a shaft whose ends are glass hard, highly polished steel pivots working in sapphire V-jewels at B. This shaft also carries pointer C, and the necessary counterbalance weights. Acting on the disk are two electromagnets D and E with copper shading coils F arranged over one-half the poles. These coils cause a shifting of the magnetic flux during each cycle which tends to rotate the disk. Electromagnet D tends to rotate the disk in a clockwise direction while electromagnet E tends to produce counter-clockwise rotation. The shape of the disk is peculiar as the left-hand side is a true semicircle around the point B, but the right-hand side is an approximate semicircle around the point G, which is slightly above the points B'.

The effect is that when the disk rotates to the right, more and more metal will come under the influence of the right-hand electromagnet E thus producing more counter torque and allowing a perfect balance between D and E.

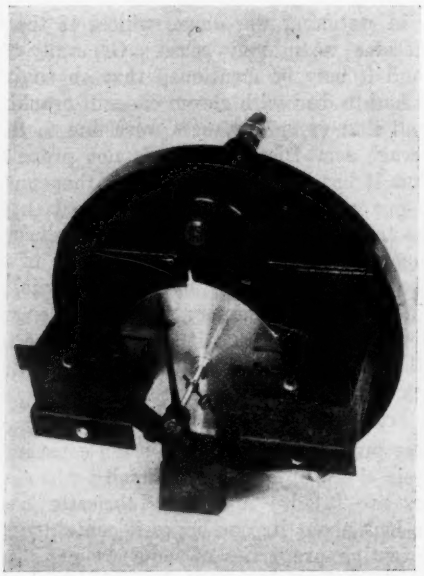


FIG. 2. INTERIOR OF INSTRUMENT IN FIG. 1

Electromagnet D is in series with a non-inductive resistor H, both being connected across the voltage of the circuit; consequently the current in this is practically constant regardless of the frequency. The electromagnet E is in series with an inductive resistor I, so that the current will be inversely proportional to the frequency of the circuit.

Let us assume that the disk is standing still, or in balance at the middle of the scale and that the frequency suddenly increases. The current in D will not increase,

but the torque will increase slightly due to the greater speed of the shifting of magnetism; however, the current in E will decrease due to increase in frequency, so the torque will decrease. This allows D to so overpower E that the disk starts to rotate in a clockwise direction. As it rotates, however, it puts more and more metal under the influence of E (due to the eccentricity of the disk), thus increasing the torque of E until finally a position is reached where the two torques again balance and the disk stops. This point would be marked with the frequency of the circuit at that point. Thus for every frequency there is a certain point where the torque will balance and the pointer come to rest.

It will also be found that if the voltage should increase or decrease it will have but little effect on the indication, as both electromagnets will be effected equally. Extremely poor wave form, or rather a wide deviation from perfect sine wave voltage, will have some effect on the indications.

It should also be noted that there are no control springs or conducting strips in this instrument. The moving element is in perfect balance mechanically and when the coils are not energized, the pointer will stay in any position, as the control is entirely electrical.

Another well-known type of frequency meter employs two coils with their magnetic axes at right angles to each other. This arrangement is shown in Fig. 4 where A and B are the two main coils. Coil A is in series with an inductance C and in parallel with non-inductive resistor D so that the current in it decreases with an increase in frequency while coil B is in series with a non-inductive resistor E and in parallel with an inductive resistor F, so that the current will increase with an increase in frequency. Acting under the influence of these two coils, is a soft iron vane G, which is suitably pivoted and which carries the pointer. It is evident that this vane cannot line itself up with the field of both coils at once, so it lines itself up with the resultant field; and as the axes of this result field will depend on the proportionate strength of each coil and this in turn on the current in each coil which again is dependent on the frequency of the circuit, it is evident that the final indication may be calibrated in terms of the first cause, or in other words, the frequency.

Another commercial frequency meter used extensively is shown externally in Fig. 5 and internally in Fig. 5a. There are a number of slender, well-tempered steel reeds R screwed to the bridge-piece B which are accurately tuned so that their periods of natural vibration coincide with the various frequencies to be meas-

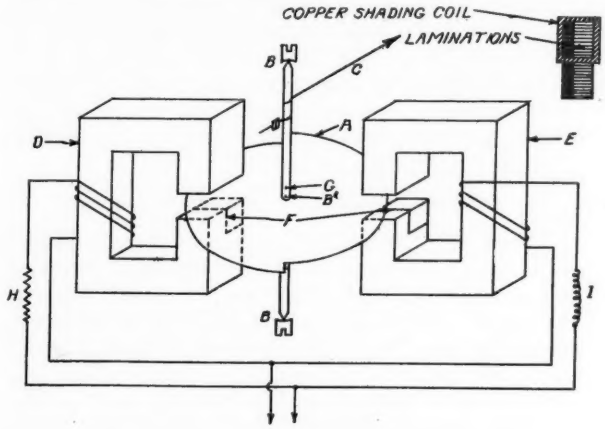


FIG. 3

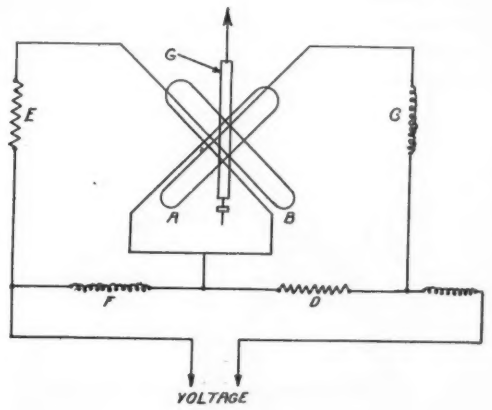


FIG. 4

FIG. 3. DIAGRAMMATIC SCHEME OF METER, FIG. 1 FIG. 4. DIAGRAMMATIC SCHEME OF SOFT IRON FREQUENCY METER

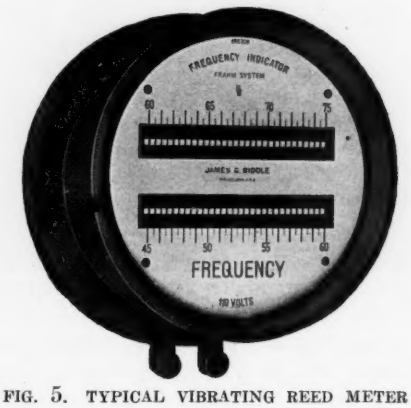


FIG. 5. TYPICAL VIBRATING REED METER

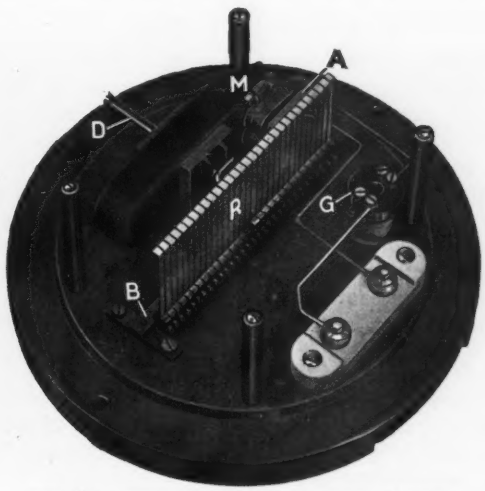


FIG. 5-a. INTERIOR VIBRATING REED METER

ured. The instrument is connected directly across the circuit to be measured (like a voltmeter) and the current after passing the current-limiting resistor G, energizes electromagnet M. This causes armature A to vibrate synchronously with the alternations of the current and this in turn causes the reed whose natural vibration period coincides with this frequency to vibrate just like a tuning fork. The ends of these reeds are bent up and painted white as in Fig. 5, thus giving a clear indication as to which reed is vibrating. This instrument has several advantages over other principles of operation as there are no moving coils, wires, springs, bearings or pivots. They are independent of variations

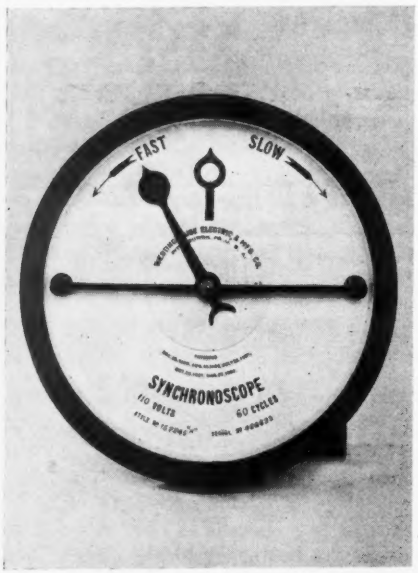


FIG. 6. TYPICAL SYNCHRONOSCOPE

in position, wave form or stray fields and by means of rod D, Fig. 5a, can be tuned to cover about 20 per cent voltage change. They consume only a few watts for operation and are almost perfect in permanence of calibration.

Special instruments may be obtained where the armature is polarized and therefore vibrates at one-half its former speed, thus giving a double-range instrument. In the portable instruments, this change in capacity is effected by a small switch; but in the switchboard type, the instrument is provided with an extra binding post.

Installing and Checking

When received from the manufacturer, the moving element of frequency meters is often secured by strips of paper and it is necessary to remove the case and remove these strips before operation.

It should also be noted that the moving element is in perfect mechanical balance before applying current. The calibration of frequency meters is most quickly checked by connecting in parallel with a portable standard frequency meter of known accuracy and varying the resistance in the non-inductive circuit until the indications on varying frequency are identical. In the induction type, a variation in the non-inductive resistance will merely shift the scale either to the right or left, but a variation in the inductive side, generally accomplished by varying the airgap in the external impedance coil, will not only shift the scale from one side to the other, but will also change the width of the scale or range of the instrument.

In the absence of a good standard, the speed of the generator (or a synchronous motor) may be taken by using a revolution counter and a stop watch, the frequency in "cycles per second" being:

$$\text{Cycles} = \frac{\text{R.P.M.} \times \text{poles}}{120}$$

If the generator shaft is not available, a cycle-counter instrument may be used and the number of cycles per minute counted with a stop watch and reduced to "cycles per second" by dividing by 60.

Synchronizing and Synchronoscopes

When the load on a d.c. system exceeds the capacity of the generator, an additional generator may be brought up to the same voltage and the two placed in parallel by simply closing the paralleling switches at any desired instant. Not so with alternating-current generators, however, as in this case they must not only have their voltages approximately equal but they must be running in synchronism and in phase: that is, they

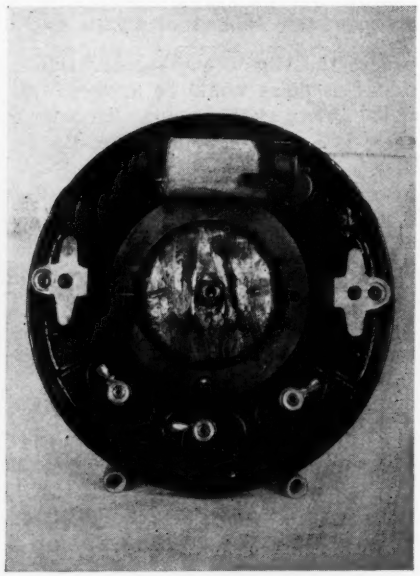


FIG. 7. INTERIOR VIEW OF METER IN FIG. 6

must be generating at the same frequency and also have the generated voltages pass through the values of zero, positive maximum, zero and negative maximum at the same instant.

To determine this condition is the function of the synchronoscope shown in Fig. 6. An internal view with the dial, damping magnet and shield removed is shown in Fig. 7, while a diagrammatic scheme of parts is shown in Fig. 8. At "a" is shown the internal fan-shaped soft iron vane "A" mounted on a pivoted shaft which carries the pointer. This vane is magnetized or polarized by a coil B which is connected in series with a resistor to the voltage of the machine, being synchronized as will be explained later. Wound around this vane and coil,

are two more windings, C and D, shown in Fig. 8 "b." The magnetic axes of these coils are at right angles to each other and also to the axis of the internal coil. Coil C is connected in series with a non-inductive resistor and coil D in series with an inductive resistor, so that the fluxes of these two coils are at right angles in space and 90 deg. of a cycle apart in time. This results in a rotating field, making one revolution per cycle.

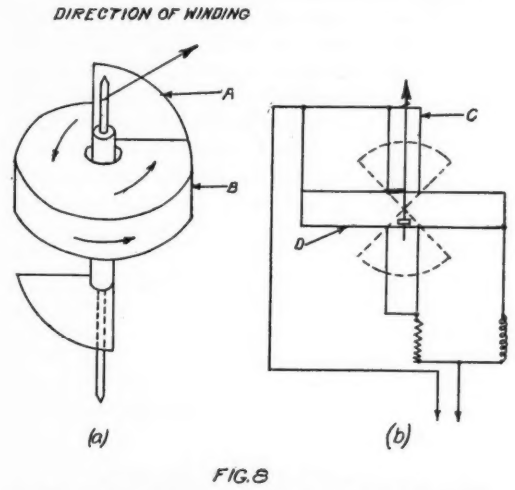


FIG. 8. DIAGRAMMATIC SCHEME OF CONNECTIONS

For the first illustration consider that the internal coil is connected to the incoming machine A, Fig. 9, while the rotating field coils are connected to the lower bus B of the running machines. Also assume that machine A is running slightly slower than the frequency of the bus. Consider an instant when the coils C and coils A are a maximum at the same instant. Coil A polarizes the vane and due to a compass-and-coil action, the vane must line up with the axes of coil C at this instant, assuming line E. F. 90 deg. later the axes has rotated to position G. H., but the magnetism of the vane has decreased to zero so there is no tendency to line up 180 deg. from the start, the rotating field has reached the direction FE, but as the magnetism in the vane has reversed, it again tends to line up as before. Two hundred and forty degrees is the same as 90 deg. The magnetism in the vane, however, has not built up to a maximum when the rotating field reaches position E F again, as it is somewhat slower (our original assumption). In fact, it does not reach its maximum until the rotating field has reached the position I J so the vane must advance this distance in order to line up its axes with the direction of the rotating field at this instant. Next cycle, it again loses a few degrees, so it must again move forward to line K L; this advancing each cycle results in a continuous rotation in the "Slow" direction, thus indicating that the incoming machine is running slow.

If the incoming machine is running fast, then the vane must move slightly each cycle in the opposite direction to meet the rotating field and this results in continuous rotation in the fast direction.

When the pointer stops, it indicates that the machines are running at the same frequency but they may not be in phase; consequently we must wait until the pointer stops over the dummy pointer, thus indicating correct synchronism. Switch C, Fig. 9, may now be quickly closed and the machine will hold in synchronism.

In actual synchronizing, it is almost impossible to get the pointer to stop on synchronism, therefore the machines are adjusted so that the incoming machine runs slightly faster than the bus, with the pointer not revolv-

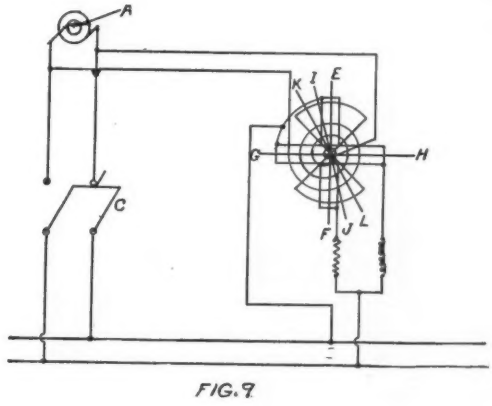
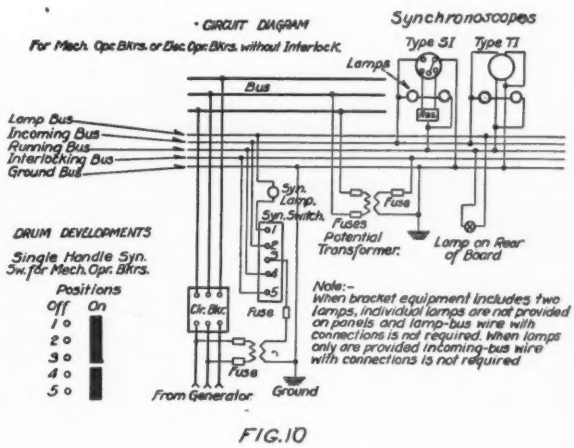


FIG. 9. DIAGRAM OF CONNECTIONS FOR SYNCHRONOSCOPE



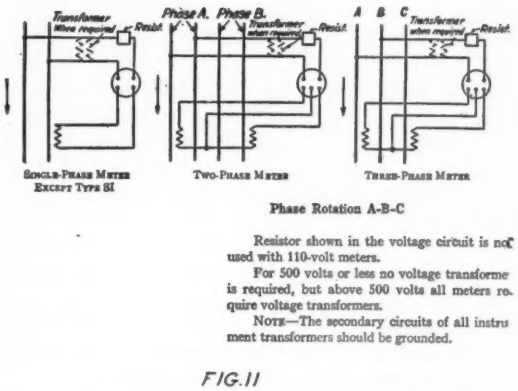

Transformer Wire required
Resist.
Phase A.
Phase B.
Transformer when required
Resist.
A B C
Transformer when required
Resist.
SINGLE-PHASE METER EXCEPT TYPE 81
TWO-PHASE METER
THREE-PHASE METER
Phase Rotation A-B-C
Resistor shown in the voltage circuit is not used with 110-volt meters.
For 500 volts or less no voltage transforme is required, but above 500 volts all meters require voltage transformers.
NOTE—The secondary circuits of all instrument transformers should be grounded.
FIG.11

FIG. 10. TYPICAL SYNCHRONOSCOPE DIAGRAMS

FIG. 11. DIAGRAM OF CONNECTIONS FOR POWER FACTOR METERS

ing faster than one revolution in 6 sec. and then quickly closing the switch as the pointer passes synchronism. With automatic oil switches or remote control switches, the manual closing must be done slightly in advance of synchronism, as the switches take a slight time to operate, which brings the actual closing at dead synchronism.

In actual practice, there are usually several machines which may be synchronized and in this case one synchronoscope will suffice for all machines, the instrument usually being placed on swinging brackets at the end of a switchboard and connected to the proper machine by plugging in on a "synchronizing bus." Typical connections as supplied by one manufacturer are shown in Fig. 10.

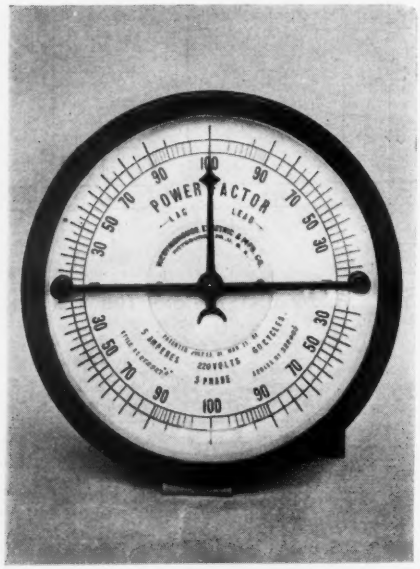


FIG. 12. TYPICAL POWER FACTOR METER

Synchronoscopes may also be supplied for three-phase service with the split-phase resistor omitted. In this case, instead of the two coils C and D, in Fig. 8, there are three coils spaced 60 deg. apart and these are fed from the three-phase voltage. The internal effect of a field rotating once per revolution, however, is identical with that of the single-phase meter.

To check the connections of a synchronoscope, first synchronize the two machines by lamps or another instrument under test. It should indicate synchronism. If a single-phase, and it indicates 180 deg. off, simply reverse the top leads. If a three-phase and it indicates 120 deg. away, spiral the voltage leads either forward or back to make it indicate synchronism. If it indicates 60 deg. away, spiral the leads to indicate 180 deg. off and then reverse the top leads. If it indicates any other position, the pointer must be shifted. If the pointer rotates "fast" instead of "slow," or vice versa, first make sure that the incoming machine is connected to the top posts, and then in the single-phase, reverse the inductive and non-inductive circuits; in the three-phase, reverse the two outside lower leads, afterwards spiraling them if necessary.

Power and Reactive Factor Indicators

Now we have our machines synchronized and the load is applied. Here again is another condition not encountered in d.c. work; i. e., the product of volts and amperes does not always equal the watts. In other words, the current and voltage is not in phase and we must multiply the product of volts and amperes by the power factor in order to arrive at the true watts. Under synchronoscopes, it was shown how the instrument indicated the phase relation between two voltages. It becomes a simple matter then to substitute a current winding for the internal coil A in Fig. 8a, and this same instrument will indicate the phase relation between the current and voltage in a circuit if connected as in Fig. 11. This also shows the three-phase connections. We do not, however, care to know the actual angle between the current and voltage, so the dial is marked to indicate the cosine of the angle which, of course, is the power factor. A typical power factor meter is shown in Fig. 12.

Sometimes it is preferable to know the sine of the angle instead of the cosine. This is called the reactive factor and the only difference between the power factor and reactive factor meter lies in the marking of the dial; the internal construction and external connections are identical. Figure 13 shows the marking of the reactive factor meter.

Checking and Adjusting

Care must be taken in connecting polyphase power factor and reactive factor meters that the phase rotation is correct. Wrong rotation will be manifested by a reading of "lead" instead of "lag." It is corrected by reversing the connections to one voltage transformer or reversing the leads to the lower outside voltage binding posts. With 100 per cent power factor on the line, the instrument should read 100 on the top scale. If it reads 100 on the lower scale, reverse the current connection. If it reads 50 lead or lag on the lower scale, spiral the voltage leads; if 50 lead or lag on the upper scale, reverse the current connection and spiral the voltage leads.

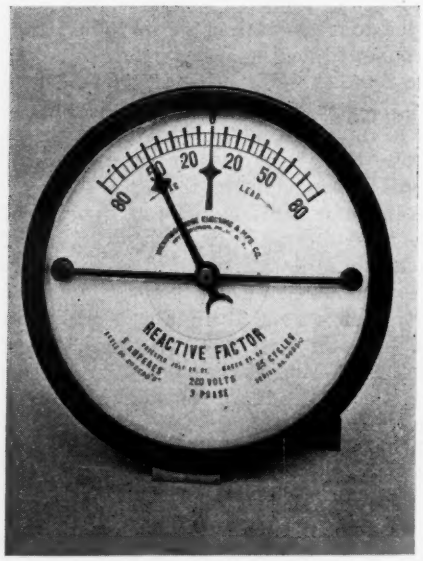


FIG. 13. SCALE CALIBRATED TO INDICATE REACTIVE FACTOR

The calibration at other points may be checked by varying the power factor of the load and comparing the

indication with the ratio of the true watts to the apparent watts as determined from the voltmeter, ammeter and wattmeter readings.

These indicators attain their greatest accuracy when the current is between 2 and 5 amp. and the voltage between 75 and 125 per cent of normal. Therefore current and voltage transformers should be chosen to give these values on the instruments.

The three-phase instruments are designed only for balanced loads so if the load is badly unbalanced, three single-phase instruments must be used. On a two-phase circuit, it is advisable to use one or two single-phase instruments depending on whether the load is balanced or unbalanced.

New Field for Automatic Substation

EQUIPMENT HERETOFORE RESTRICTED TO RAILWAY WORK FOUND SUITABLE FOR COMMERCIAL SERVICE

THERE has recently been placed in operation by the St. Paul (Minnesota) Gas Light Co. an automatic substation supplying power to the Edison three-wire distribution system. The equipment in this station consists of a 500-kw. 250-125-v. direct-current compound, commutating pole, compensated generator directly connected to a 4000-v., three-phase, 60-cycle, 1200-r.p.m. synchronous motor together with complete automatic switching equipment.

This substation is located in the sub-basement of the new Harm Building which houses the new Capitol Theater devoted to the cinema art, many shops and floors of offices and the St. Paul Amusement Co., devoted to bowling and billiards.

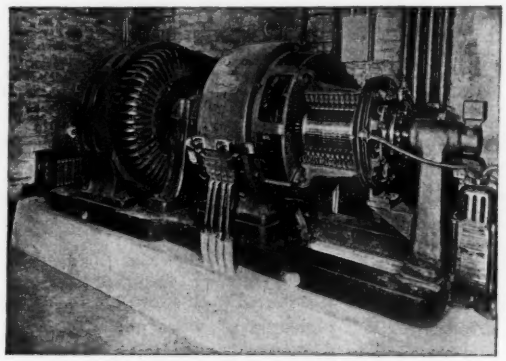


FIG. 1. MOTOR GENERATOR SET INSTALLED IN NEW HARM BUILDING

To supply this establishment with service from the light company's network, would require not only additions to the capacity in an existing substation, but the addition of copper to the distributing network as well. In the nearest substation, no space is available for the installation of an additional unit. The automatic substation, designed to give to this building a preferred service, solves the problem. During periods of light load, the substation is idle, the building being supplied from the Edison voltage below a predetermined value, the equipment receiving a starting impulse from a contact-making voltmeter, puts the substation into service. Operation of the station is continued until the load drops below a predetermined value and remains at or below this value for a given length of time when the station is cut out of service by the action of a small motor operated timing relay. The system direct-current voltage is now above the setting of the contact-making voltmeter, so that the station remains idle until drooping network voltage indicates further demand.

While the substation is in operation, it is paralleled with a network until the current to it is in excess of one-half the capacity of the machine, when a small amount of resistance is cut into series with the feeder, thus drooping the voltage to effect a dropping of load. This is accomplished by the functioning of direct-current, reverse current relays controlling the operation of the

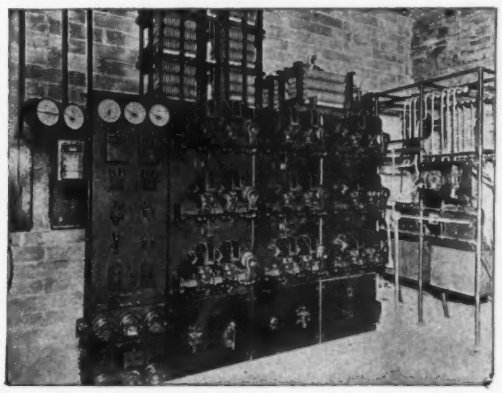


FIG. 2. CONTROL AND SWITCHING EQUIPMENT IN HARM BUILDING SUBSTATION

electrically operated contactor switches. When the substation is idle, the current inflow to the building from the network is not limited. It is thus seen that this building receives a preferred service. An outage on the direct-current network leaves the building to be supplied from the substation. Conversely, an outage of the substation leaves the building to be supplied from the network. This combination thus establishes good voltage regulation of the service supplied to this location.

Protective features similar to those supplied for railway automatic substations and other features peculiar to this type of equipment afford complete protection to the apparatus.

The success of this equipment as shown by the initial operation is already assured. It demonstrates a new application of automatic switching which opens the way to perhaps even a greater field than any that has so far been entered with this class of apparatus.

Supporting Open-Work Conductors on I-beams

BY L. A. BARTH

WHEN installing a lengthwise run of slow-burning-insulation conductors along the truss chords of a steel-construction mill building, it is usually more economical (where there are only one or two circuits in the run) to support the insulators for them on light castings which are called "universal insulator

supports." These castings clamp, with one set screw, on the bottom flange of an I-beam or channel. Where there are a number of conductors in the run, a good method is that shown in Figs. 1 and 2. With this scheme a piece of wood, into which the screws supporting the porcelain cleats turn, is clamped to the lower face of each I-beam with a supporting iron (C_1 and C_2, Fig. 2). As divulged in the general view of Fig. 1 (although but a single conductor is shown in the run illustrated) any reasonable number of conductors can be held to one supporting board by using for the supporting block a piece of board of sufficient length. The so-called "Band D" type of cleat is probably the best for this work. At the end of each run, as shown at E (Fig. 1) a terminal iron with an insulated "take-up" of some sort or other should be used.

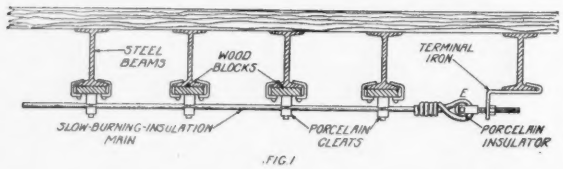


FIG. 1

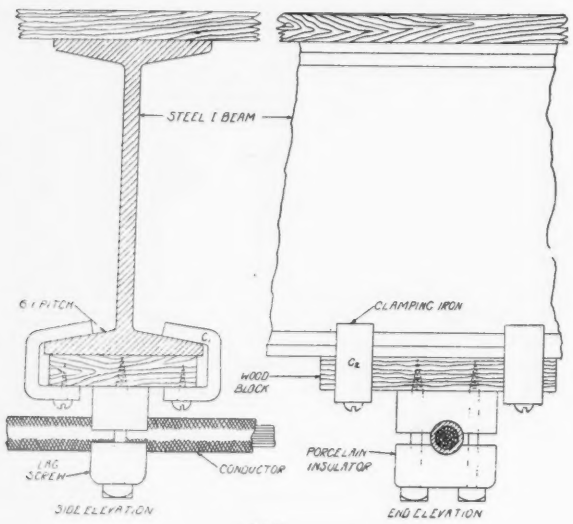


FIG. 2

FIG. 1. SHOWING HOW OPEN-WORK CONDUCTORS MAY BE SUPPORTED ON I-BEAM

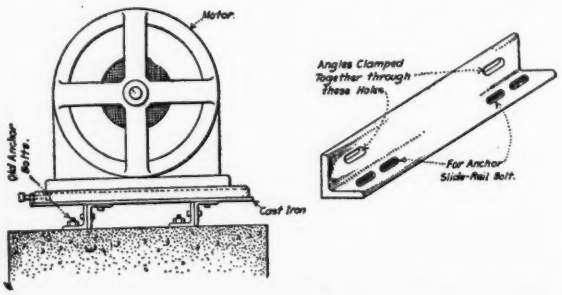
FIG. 2. DETAILS OF SUPPORT AT I-BEAM

The clamping irons may, ordinarily, be made of ⅛ by ⅞-in. strap iron. A hole to accommodate the wood screw is drilled in each clamping iron, in the location indicated in the picture. As suggested, the upper leg of each clamping iron should be bent to a 6-to-1 pitch with the horizontal to fit the upper face of the I-beam flange. Hence, when the clamping iron has been pushed on to the flange, because of the wedging effect due to the slope of the flange, the wood block is clamped up tightly. For supporting small wood blocks, two clamping irons are sufficient, one at each of two opposite corners. If the support is longer, four clamping irons, one at each corner, are necessary. When the block is very long, six may be used, one at each corner and two in the middle.

Angle Irons for Adjustable Motor Base

By M. M. Gable

OCCASIONALLY in mounting small motors on concrete foundations, it is desirable to use motor base plates of different sizes on the same foundation without changing the location of the anchor bolts. The accompanying illustration shows a construction which has been used in an industrial plant to accomplish this result. For each motor, four identical angles, each provided with holes as shown in the drawing, are prepared. Two of the angles are bolted down to the top of the foundation, and another pair of angles bolted down to the foundation angles.



USE OF ANGLE IRON SUPPORTS IN CONSTRUCTING ADJUSTABLE MOTOR BASE

A considerable leeway in adjustment is provided by the slotted holes in the angles, and almost any reasonably sized adjustment can be obtained. Furthermore, the four-angle combination permits of the ready alinement of the motor with the line shaft or machine pulley which it is to drive.—Electrical Record.

Twelve Things to Remember

By J. B. Dillon

IF it is no harm to tell a good joke twice, surely there is no harm in passing along wholesome advice.

The little nuggets that follow are credited to the Marconi Service News:

Remember:

The value of time.
The success of perseverance.
The pleasure of working.
The dignity of simplicity.
The worth of character.
The power of kindness.
The influence of example.
The obligation of duty.
The wisdom of economy.
The virtue of patience.
The improvement of talent.
The joy of originating.

THE COLORADO house of representatives defeated the bill that would, if it had become a law, deny to anyone except a citizen of the United States, an engineering license, in Colorado. The Engineering Council who favored the bill will draft a similar one and fight for its adoption.

Refrigerating Plant Economies and Capacities

PRACTICE WHICH BEARS DIRECTLY ON THE ECONOMY AND CAPACITY OF THE PLANT IS DISCUSSED BY I. L. KENTISH-RANKIN

WITH WARM weather approaching, with an unprecedented shortage of natural ice because of an open winter and because the market price of ice has already risen, the slogan of the refrigerating engineer this summer ought to be "Most ice in the shortest time."

Ice plants are getting into full swing in readiness for a busy summer when the demand for manufactured ice will surpass previous years. Economy in production and ways of increasing the output of existing plants thus loom as big problems to the refrigerating engineer, and therefore the operating details of the ice plant are of foremost concern. Minor details last year assume the magnitude of major matters this year if by their summation they are able to bring about a higher rate of ice production.

Small savings are cumulative in effect and together combine to bring about bigger savings. As the engineer keeps his plant running, various ideas come to him and many of these he turns to account by putting them into action. Some of the matters touched upon here may appear as truisms to many of the older men in the refrigerating game; they are new to many of those whose plants suggested the need of these recommendations. In any case, suggestions that are known but have been forgotten are of little use. If a reminder brings back forgotten ideas and enables them to be put to use for more ice at less cost this article will have served its purpose.

Remember the problem today, and in the immediate future, is to make more ice for less cost with the existing plant. Many radical changes can, however, often be made without much disturbance and with comparatively little interruption to service. Many such changes are well worth while.

For example, replacing an induction motor with one of the synchronous type immediately reduces the power consumption from 2 to 5 per cent and eliminates power factor troubles. Changing over from distilled to raw water ice brings immediate economies where the quality of the water permits of such a change. Installing a water softener reduces the time for ice making, produces better ice for less cost and eliminates the complication and annoyance of core pumping.

For the average ice plant the real problem is not what to do, but where to start, when it comes to improving operating conditions.

Compressors

WHAT CAN be done to increase the economy and capacity of existing compressors? Increasing the compressor speed is, of course, a common method of increasing the rate of refrigeration. The superiority of constant-speed machines over variable-speed machines has been proved; but there are many advantages in changing the speed of constant-speed compressors for periods of time, as for one week or one month.

With motor-driven, belted units speed changes may be made by changing the pulley ratios of both pulleys or of either the driver or the driven pulley according to circumstances. It is wasteful to change the speed by varying the speed of the induction motor as both efficiency and power factor decrease rapidly at partial speeds. Flywheels should not, obviously, be operated at speeds higher than those for which they were designed because of the danger of explosion or collapse. The stress in the rim of a flywheel increases with the square of the speed; double the speed and the stresses will be four times greater. Where pulley changes are to be used as a method of controlling speed, the pulleys should, obviously, be chosen for the speed at which they are to be used.

Information furnished by the manufacturers will serve to denote whether or not a certain machine may safely be speeded up, to take care of the heavy demand that is expected this year. The following will show the great possibilities that lie in increased speed.

Consider a vertical, 15 by 20 compressor with a rating of 50 tons at 72 r.p.m., a standard machine. If this

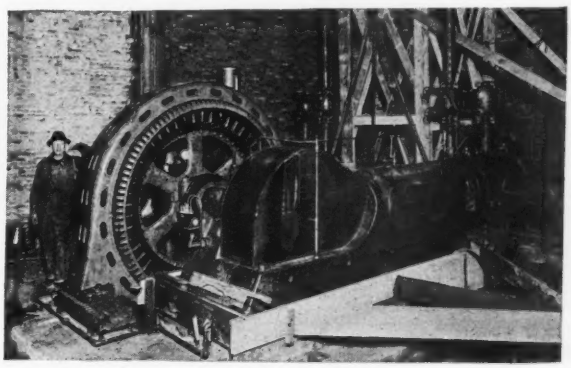


FIG. 1. 600-HP. SYNCHRONOUS MOTOR DRIVING COMPRESSOR

be a better unit and the pulley is changed for a compressor speed of 150 r.p.m., the capacity will be increased to 100 tons, or a 100 per cent gain in output.

If we go still further, and direct connect this machine to, say, a synchronous motor, and so eliminate friction, belt slippage, etc., so that the speed remains 150 r.p.m., the ice-making capacity will be increased a further 25 per cent to 125 tons or a total of 125 per cent by direct connecting and doubling the speed. There will be additional gains in lower operating costs, conservation of floor space, elimination of belt losses and belt maintenance, and, if a synchronous motor is used, higher efficiency and the ability to control power factor.

This is a matter that ought to be given serious consideration by every ice plant now using induction motors and belt drive.

Other flexible methods of operation during slack or busy seasons are changing flywheels so as to reduce or increase capacity, the use of one cylinder of a twin-cylinder machine by taking off one connecting rod or changing one rod and the flywheel. These are methods

that are frequently employed, but which might, in the interests of economy, be used more often than they are.

The majority of engineers check up their compressors at the beginning of a season and presume they are in good condition and properly adjusted unless something happens to contradict the assumption. If a machine is taken apart and then put together again in the same way, why should it not be in condition? There is only one way to tell, ultimately, whether a machine is in best working condition, and that is by performance. This takes time; there are so many variable factors, that underlying causes may mask each other, and some source of loss, such as excessive clearance, sluggish valves or excessive valve spring tension may exist and persist for an entire season unsuspected; but it will reduce plant capacity and increase plant costs.

It is advisable to take an indicator diagram on each compressor at least once a year, in ample time to make any changes that may be indicated before the busy season starts. It is a good plan to take a diagram after any radical adjustments have been made that might affect machine performance. The indicator diagram brings to light conditions that might be serious or insignificant but which could, nevertheless, be easily remedied for plant betterment. The two accompanying diagrams show how the indicator can help the engineer keep tab on his machines.

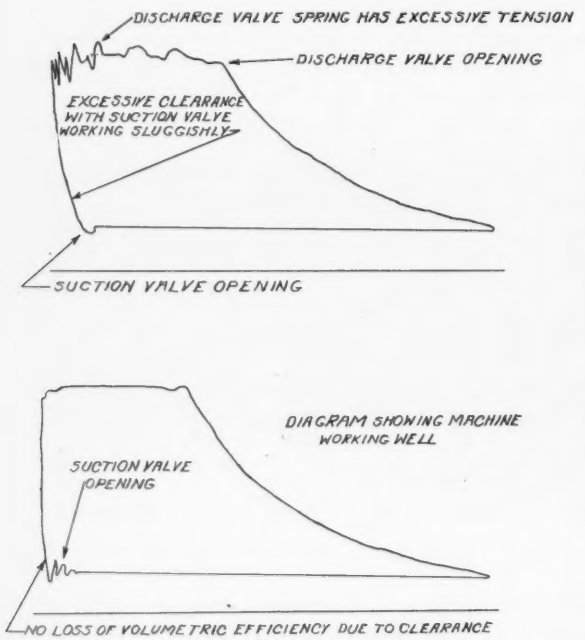

DISCHARGE VALVE SPRING HAS EXCESSIVE TENSION
DISCHARGE VALVE OPENING
EXCESSIVE CLEARANCE WITH SUCTION VALVE WORKING SLUGGISHLY
SUCTION VALVE OPENING
DIAGRAM SHOWING MACHINE WORKING WELL
SUCTION VALVE OPENING
NO LOSS OF VOLUMETRIC EFFICIENCY DUE TO CLEARANCE

FIG. 2. INDICATOR DIAGRAMS SERVE AS AN X-RAY TO SHOW UP COMPRESSOR OPERATION

The upper diagram shows an 18 by 28, 72-r.p.m. compressor in which the discharge valve spring had excessive tension and the suction valve had sluggish action. Further, the clearance was excessive, which reduced by about 20 per cent the volumetric efficiency of the machine. The lower diagram shows the machine after it had been overhauled. It was then ready to make the most of a busy season.

Oil Separator

The cost of lubricant is a small item in the total cost of operation; but the higher the oil cost the greater the likelihood that oil is causing losses throughout the system in different ways. One engineer will use two to three times as much oil as another engineer with an apparently identical plant. If the oil separator is efficient and of sufficient capacity and is properly located and maintained, excessive oil consumption means only higher lubrication costs; otherwise it means loss of plant economy due to oil entering the condenser and expansion coils.

A careful record of all oil used should be kept and careful inspection made from time to time to ascertain whether oil is entering the piping. The oil separator should be emptied often enough to insure removal of the oil; sometimes once or twice a season suffices while in other instances once a week is necessary. A check of the oil fed to the compressor and that removed from the separator is a good indication as to the amount of oil passing into the pipes.

The two most important factors in preventing oil troubles are the location of the oil separator and the choice of oil. The closer the separator is to the compressor the lower should be the viscosity of the oil because of its lower vaporization point. An oil with higher viscosity may be satisfactory when the oil separator is farther removed from the compressor as greater opportunity exists for vaporized oil to condense before it reaches the separator.

Lubricants for refrigerating machines should be carefully chosen, as improper characteristics will invariably result in difficulties and not only higher operating costs, but possibly forced shut-downs. An oil to be suitable must have a high flash point, around 368 deg. F.; a low congealing point, preferably around minus 24 deg. F.; and high viscosity, say, 3.93 Engler.

Keeping the compressor temperature down not only reduces the tendency to decomposition of the ammonia, but lessens the vaporization of the lubricant and consequently the amount of oil that passes over the oil separator to the condenser.

Oil is a good insulator and quickly reduces the conductivity of condenser and expansion surfaces. It clogs up pipes and in this way still further reduces refrigerating economy. Periodic blowing out with air and steam should be undertaken often enough to insure minimum amount of oil present in the system.

Where considerable oil has congealed upon the condenser tubes and there is insufficient time to clean in the ordinary manner, shutting off the water upon one section or stand at a time and allowing the oil to thin out under the effect of the heat, enables the oil to drain off. If oil is known to have coated the expansion coils, a quick method of removal is to operate the system backward, that is to say, pass the hot ammonia back through the coils so that the oil becomes heated and thin.

In the smaller plants oil is often blamed for discoloration of ice. If this is true, there is little excuse. Whether or not oil is to blame for discoloration can readily be determined by the shape of the discoloration. A fan-shaped discoloration indicates that oil was the cause. If the discoloration penetrates through the ice

without assuming any definite formation or shape, rust and not oil is the cause.

It is probably true that the majority of ice plants use an excessive amount of lubricant for the compressors. Much of this is needlessly wasted because of lack of an oil filter.

The way to reduce oil costs and troubles to the minimum is to buy the best oil on the market; filter it frequently. Endeavor to prevent atomization and vaporization of the oil not only by using an oil of high viscosity and flash point but also by keeping the compressor discharge temperature below 150 deg. F., by freezing back if necessary (which also reduces the decomposition of the ammonia). Locate the oil separator advantageously; adopt one of ample capacity and keep it in efficient condition.

The Condenser

Although less spectacular than the compressor, tanks and other auxiliaries and less prominently located, the condenser is one of the most important factors in the whole plant. Many conditions may exist insidiously and unsuspected and so curtail production and increase costs.

Plant capacity is often reduced because of insufficient condenser capacity resulting from insufficient initial cooling surface or a reduction in effective cooling surface for reasons mentioned later. Pipe is comparatively cheap so that additional banks of tubes are often beneficial. Twelve or possibly 6 sq. ft. of cooling surface per ton of refrigeration may suffice sometimes, but the use of ample surface to care for any condition that may arise may save disaster and reduce troubles during hot weather and a shortage of cooling water.

Too much surface is objectionable, but less so than too little. It is sometimes economical, and always advantageous as to flexibility to have enough surface to permit cutting out stands for repairs, etc., and to be able to cut down on the cooling water during cold weather or restricted refrigerating. A condenser arranged for dual operation, either element alone or both elements in parallel, makes for economy in operation and gives security against condenser troubles.

Not uncommonly, the condenser is located in a warm location or in some out of the way place where air circulation is very poor. Air circulation helps the water diffuse heat and so reduces the amount of water required and increases condenser capacity. Air ventilation costs nothing and should, therefore, be utilized to the full. Sometimes, some form of chimney effect proves worth while as a method of increasing the rate of heat dissipation.

Condensers cannot be efficient unless clean. Oil, scale and dirt form with time and not only tend to clog up the pipes, but lower the heat conductivity. Non-distillable gases also act to lower the effective cooling surface so that they should be minimized. One of the best ways to do this is to install one or more valves at the condenser so as to allow the non-distillable gases to escape to the atmosphere while the distillable gases are liquefied by the condenser and returned to the system.

Double-pipe condensers are more likely to suffer from dirt than other types because they are more troublesome to clean. Increasing the water supply is a costly way of reducing the effects of restricted cooling surface due to oil, scale and dirt. Condensers should, therefore, be thoroughly washed out as often as required, which depends upon the individual plant and the effectiveness of oil separators, etc.

Back-washing at least once a week is generally worth while as it removes precipitates before a hard scale can be formed. It is often advisable to use a special pump and apply hydraulic pressure between 80 and 100 lb., going through each coil one at a time. This should be done before the ice-making season starts. Scale tends to form most rapidly where the heat is greatest, which is on the coils, usually the top ones, where the discharge gases enter the condenser. For these a stiff wire brush or tube scraper is very useful. It often pays to take out the scale-baked top tubes at the end of a season rather than spend money on labor for cleaning them. These tubes are quite good and can be used elsewhere where heat conductivity is not an important factor.

A close watch upon ammonia and cooling water temperatures gives an accurate indication of the condition

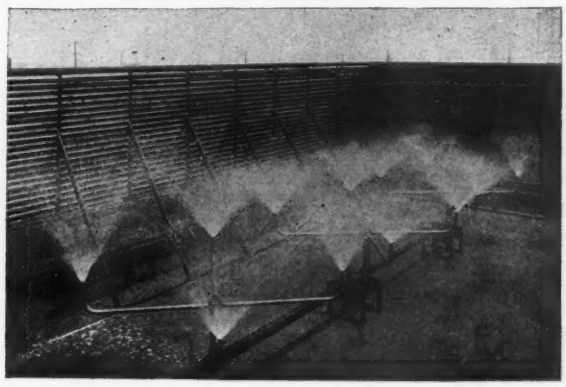


FIG. 3. TYPICAL SPRAY INSTALLATION ON ROOF

of the condenser. If there is a temperature difference greater than from 2 to 3 deg. F. between the ammonia leaving the coils and the incoming water, the heat transfer is being interfered with, probably because of scale, oil and dirt. Increased condenser pressure is another indication, although conditions will have become very bad before the pressure increase has become noticeable. Increased condenser pressure may indicate the accumulation of non-condensible gases, dirty tubes, too high condensing water temperature for a given cooling surface, an excessive amount of ammonia in the system, or insufficient cooling water. With condensers of the Block type, high condenser pressure indicates too little ammonia in the system.

As high condenser pressure means increased power consumed, greater wear and tear on apparatus, increased liability of leaks and forced shut-downs, condenser pressure should be closely watched and every effort made to keep it down to the minimum. Purging condensers is necessary, but it involves an expense, so that it should be resorted to as required and not as a convenient remedy.

Parallel-flow condensers should in many cases be reconnected for counter-current flow, thereby increasing the capacity some 35 per cent. This simple change may

be an inexpensive way of obtaining increased capacity. The condenser is such an important factor in affecting plant capacity and plant economy that it should receive close attention and deliberate selection and supervision even though it continues to work without them.

Ammonia Receiver

There is a tendency to fail to appreciate the advantages of having a liquid or ammonia receiver of ample capacity, properly located. In many instances, it is found that the receiver is too small, is not sufficiently insulated and not properly or wisely located.

As the economy and output of the entire plant depends upon ammonia temperature, it should be obvious that the receiver should be well insulated to prevent the absorption of heat. Yet too often this matter apparently receives scant consideration. To make conditions worse, the receiver is frequently found to be

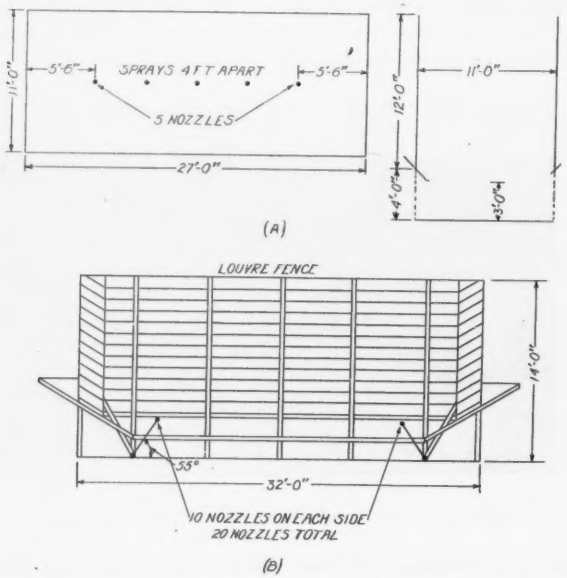


FIG. 4. INTERESTING METHODS OF OVERCOMING LACK OF ROOF AREA

installed in a warm or even hot location instead of being put away where the temperature is as low as possible. Is your receiver located high up in the compressor room where the rising warm air reaches it?

It is desirable that the receiver have such dimensions that it be capable of holding the entire charge of ammonia in the system so that should it be necessary to empty the system, the procedure can be executed as quickly and economically as possible. Usually, lack of receiver capacity necessitates filling drums with ammonia and divers other complications that result in protracted delay in starting up again and high labor cost as well as loss of ammonia. A further advantage of generous receiver capacity is that non-condensible gases may be collected and drawn off through valves at the top of the receiver instead of being allowed to circulate through the system to slow up refrigeration and lower economy.

Every receiver should be fitted with one or two gage glasses to indicate at all times the amount of ammonia in the system. This suggestion is deprecated by many engineers who have had trouble due to the glasses breaking, but the presence of a gage proves useful much oftener than troublesome.

Cooling Water

Average ice plants require anywhere from 200 to 800 g.p.m. of cooling water. Water economy is, therefore, quite a factor in over-all economy because of the cost of water and the power required to handle it. The cost of city water has been increased in many cases as much as 50 per cent, effective for 5 yr. usually, so that ample time and ample incentive exist to make economies in this matter.

With the high water rates now effective, many plants would find it cheaper to pump their own well water in preference to purchasing city water. In any or both cases, it is in the majority of cases more economical to use the same water over and over again instead of using it once and allowing it to go to the sewer. If this be done, cooling apparatus will be required. By proper care, the water waste may be reduced to 20 cu. ft. per ton in many plants.

With the choice of cooling apparatus resting between towers or sprays, the latter seem to find special favor for ice plants located in towns. Sprays cost considerably less than towers; occupy less overhead space; are more easily installed; may be taken out of service in sections or elements and the number of spray heads varied with the load and the season.

With present prices, a roof spraying installation will cost between $.80 and $1.00 per gal. sprayed per minute. In localities such as Chicago where the air is corrosive, metallic towers have had a life that varies from 2 and 3 yr. to 10 yr. if well maintained. Where towers are used, wood is preferable to metal on the score of longer life. The tendency seems to be to adopt sprays in preference to towers as they possess great flexibility which enables power and water to be saved during light loads and cold seasons.

Sometimes difficulty is encountered in obtaining sufficient area for sprays where insufficient roof surface is available. The accompanying illustrations show two interesting methods of increasing the cooling effect, where there is restricted area. In the one sketch there are 20 spray heads, arranged in two rows of 10 each and placed at an angle of 55 deg. so that the sprays would converge if the effluent maintained the direction with which it leaves the nozzles. This arrangement creates considerable draft, which helps cool the water as well as enables 20 nozzles to be efficiently used in a limited space.

The other sketch shows an arrangement by which air is induced through the openings at the bottom of the louver fence, so creating considerable air velocity and efficient cooling. The louver arrangement shown furthermore reduces the per cent of water loss due to strong winds which may prevail in certain localities.

The desirability of locating the condenser where there is good cool air circulation is obvious. Not a few companies have found it convenient to locate the cooling sprays directly above the condenser. Surrounding the condenser with a wooden housing designed for rapid air circulation through it, and mounting the sprays outdoors immediately above conserves roof space or utilizes

to the full that which exists and makes a compact and efficient layout.

Ice-Making Water

Do you know your water cost per ton and how much of this is needlessly wasted? The matter is not a major one, but it is one that presents an opportunity to save money nevertheless.

Impure water requires a longer time for freezing than water from which the impurities in suspension have been filtered out. A filter shortens the time for freezing, thus, increasing plant capacity.

About 50 lb. of water is drawn off by core pumping per 400-lb. can of ice. This is a small item for one can, but it is a large item considering the number of cans involved during 24 hr. or 1 yr. of service. The heat involved is also deserving of consideration, as core water has a temperature of about 32 deg. F. when removed. Filtering reduces the amount of core water to be removed and so reduces the time for freezing, saves water

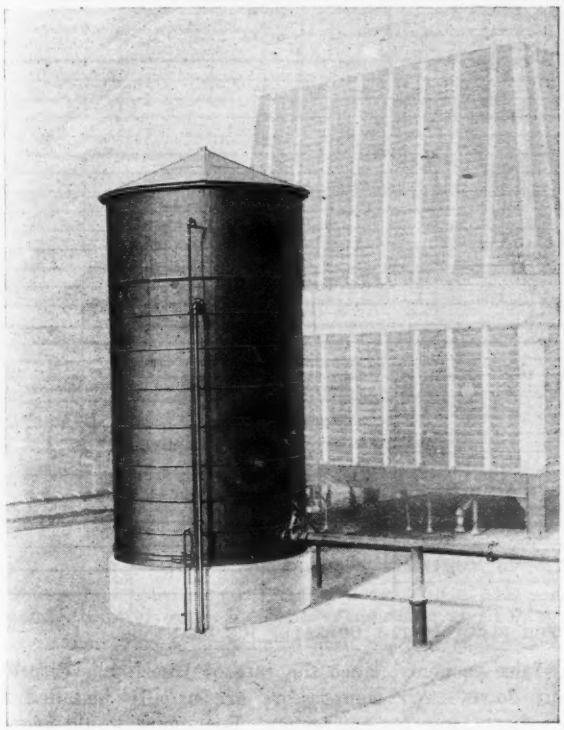


FIG. 5. TYPICAL WATER-SOFTENING INSTALLATION WHERE CORE PUMPING HAS BEEN ELIMINATED AND BETTER ICE IS NOW MADE IN LESS TIME

and heat. Some companies return core water to a precooler for future use, but the complications hardly appear to warrant this arrangement.

Pumping cores twice instead of once has been found to reduce the time for ice making by about 2 hr. in some cases; but what is saved in time is made up by higher cost.

Water softening or treatment is another way of improving the quality of ice and reducing the time for making it. Softened water produces clear, pure ice and is thus invaluable where the public demand clear ice and where there is keen competition. Plant capacity is also increased 8 to 10 per cent, labor cost is reduced and production costs are lowered where softened water is employed, as core pumping is not then necessary. Absence of core pumping and all its attendant complications and a lower ammonia pressure are big factors in favor of water softening.

Most new plants in the vicinity of Chicago are installing water softeners, which implies the removal of solids in suspension by filtration. The cost of softening depends upon the amount of water treated and the constituents of the water. In Chicago territory the cost is about 1 cent per ton—a negligible item, and one which is repaid many times in the form of better ice, quicker freezing and lower labor and power costs.

Instruments

Instruments have a way of indicating improperly because of being deranged or because they are out of

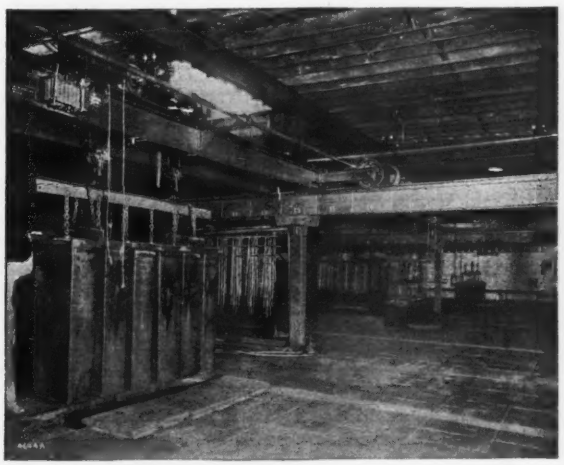


FIG. 6. SIX CANS ARE PULLED AT ONCE IN THIS PLANT, THUS REDUCING LABOR AND LOSSES

calibration. Unless this fact is known, loss of economy and worse troubles may develop. The best safeguard is eternal watchfulness, which, by the way, is the way to maintain efficiency and make the most of the instruments.

For example, pressure gages become clogged at their connection, with dirt and scale, and foreign matter may become lodged in the instrument itself. The indication may be correct at 50 lb. but may be 20 to 30 lb. low at 150 lb. Needlessly high pressure may be carried under this condition, causing needless expense and encouraging leaks, ruptured tubes and similar troubles. On the suction side, an indicated pressure of 18 or 20 lb. (usually what is desired) may in reality be only 14 or 16 lb. and as a result it may be difficult to keep temperature down; lack of liquid, improper mixing of new ammonia with that already in the system and other possible causes of inability to keep temperatures down may be blamed whereas a defective gage is the trouble—and the most easily remedied trouble at that.

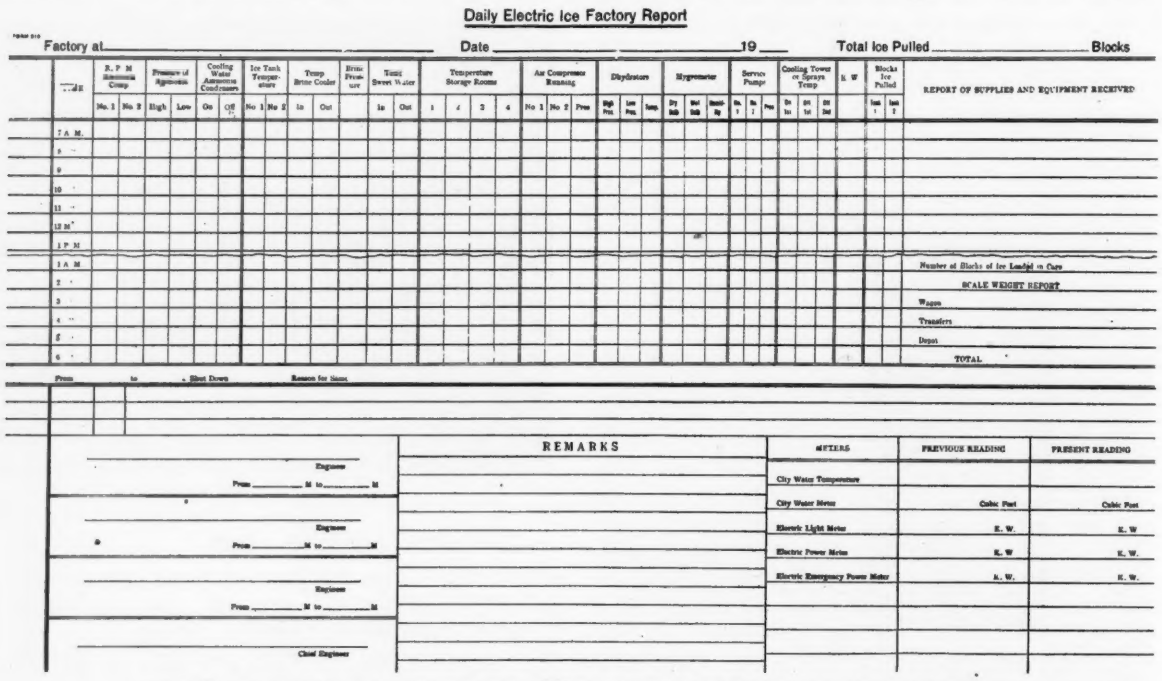
Thermometers sometimes get off calibration because of an inherent defect in the instrument or, more commonly, because the thermometer has gradually moved away from the surface with which it is supposed to be in intimate contact or because a film of dirt, scale or

other heat-insulating material has built up around the bulb. Faulty temperature indications may lead to a slowing down of refrigeration for days and even weeks, hence thermometers should be carefully watched for accuracy and they should be periodically inspected for physical condition.

Electrical fittings such as switches and circuit breakers corrode under the influences of the fumes evolved from the ammonia and brine. Electrical contacts assume higher resistance and so result in voltage drop, heating and energy losses. Exposed surfaces should be reduced to the minimum and switchboards placed where corrosive fumes are not greatly in evidence. Erratic fuse failures, with the resulting shut-downs have been traced in many instances to overheating as a direct result of corrosive gases. A very thin coating of vaseline between switch contacts and the knife or blade reduces contact resistance and mitigates corrosion. Various forms of amount of coil surface, thereby reducing the initial investment. This is often desirable. Much loss of capacity occurs from sluggish circulation and diluted brine. Brine should not be allowed to vary in density from 60 deg. for sodium and 80 deg. for calcium solution. Dilution may easily occur from leakage, overflow from cans during filling, etc., so slowing up the rate of freezing. Frost is another cause of slower freezing, and is due, in turn, to dilution. The brine should be tested regularly for acidity or neutrality, as a brine that is acid tends to cause pockets and impede circulation. The use of inferior qualities of calcium may result in the formation of a thin scale, which, acting as insulation, hinders refrigeration.

The brine deserves careful watching at all times.

Air agitation is sometimes found to be insufficient because air compressors are overloaded or because of air leaks at joints, faulty fittings, etc. Lack of agitation


Daily Electric Ice Factory Report

Factory at _____ Date _____ 19__ Total Ice Pulled _____ Blocks

HOUR	R. P. M. Ammonia Comp. No. 1	R. P. M. Ammonia Comp. No. 2	Pressure of Ammonia High	Pressure of Ammonia Low	Cooling Water Ammonia Condensers On	Cooling Water Ammonia Condensers Off	Ice Tank Temperatures No. 1	Ice Tank Temperatures No. 2	Temp Brine Cooler In	Temp Brine Cooler Out	Brine Pressure	Tank Sewer Water In	Tank Sewer Water Out	Temperature Storage Rooms 1	2	3	4	Air Compressor Running No. 1	Air Compressor Running No. 2	Air Compressor Running Press	Dehydrators High Pres.	Dehydrators Low Pres.	Dehydrators Temp.	Hygrometer Dry Bulb	Hygrometer Wet Bulb	Hygrometer Humidity	Service Pumps No. 1	Service Pumps No. 2	Service Pumps Pres.	Cooling Tower or Sprays Temp In	Cooling Tower or Sprays Temp Out	Cooling Tower or Sprays Temp Del	K. W.	Blocks Ice Pulled Test 1	Blocks Ice Pulled Test 2	REPORT OF SUPPLIES AND EQUIPMENT RECEIVED
7 A. M.																																			
8 "																																			
9 "																																			
10 "																																			
11 "																																			
12 M.																																			
1 P. M.																																			
1 A. M.																																			
2 "																																			
3 "																																			
4 "																																			
5 "																																			
6 "																																			

Number of Blocks of Ice Loaded in Cars

SCALE WEIGHT REPORT

Wagon

Transfers

Depot

TOTAL

From to Shut Down Reason for Same

Engineer From M to M

Engineer From M to M

Engineer From M to M

Chief Engineer

REMARKS	METERS	PREVIOUS READING	PRESENT READING
	City Water Temperature		
	City Water Meter	Cubic Feet	Cubic Feet
	Electric Light Meter	K. W.	K. W.
	Electric Power Meter	K. W.	K. W.
	Electric Emergency Power Meter	K. W.	K. W.

FIG. 7. DESIRABLE FORM OF REPORT SHEET FOR ELECTRICALLY OPERATED ICE PLANT

lubricants are used to protect exposed metallic surfaces, such as electrical fittings, against attack by ammonia. Few of these are really effective as they are, themselves, acid-reacting. It is better to use blackened rather than bright surfaces for electrical fittings.

Miscellaneous Economies

Lack of sufficient expansion coils is a frequent cause of inability to keep temperatures down. Pipe is comparatively cheap and it is far better to have too much pipe than too little, as an excess can be remedied by cutting out sections, while it leaves a margin for safety during emergencies and specially hot weather and heavy loads. A few hundred feet of 2-in. pipe additional would carry many plants over a predicament and would prove vastly cheaper than higher compressor speeds used for this same purpose.

There seems to be a general tendency toward employing a higher rate of brine circulation and so reduce the is false economy, since the rate of freezing is directly cut down. Air compressors are usually installed in duplicate, one for emergency. Economies would accrue were one set smaller than the other, for use during light loads when minimum air is required. Another opportunity to save here is by using direct-connected compressors instead of the typical belt-driven unit which on the score of economizing floor space always seems to have a belt tightener. The saving in power consumption would very quickly pay for the slightly higher cost of a direct-connected compressor.

These remarks apply, likewise, to the circulating pumps for condenser cooling water. If one unit were smaller than the other, the circulation at light loads would be more economically obtained.

Insulation is not a matter that varies from day to day except in some minor way here and there. Insulation should be examined and repaired before the season opens up. It is invariably cheaper to insulate thoroughly

against losses than continually to expend power to make up for them.

Losses from the tank room to earth and similar losses can be prevented once and for all; and for this reason should be properly taken care of; other losses may vary from time to time, as the escape of heat on the tank room floor. Ignorant and careless workmen not realizing, can waste considerable heat by leaving tank covers off for needlessly long periods of time when filling cans, sucking cores, etc. Covers should be replaced as quickly as possible for the sake of reducing losses as well as for sanitary reasons. Some companies actually use a canvas mat on top of the tanks, so as to prevent heat losses and prevent dirt from getting into the cans. While many companies continue to take out one tank at a time, others are handling three, four or six tanks as a unit; tank covers span two or three tanks instead of only one. This makes for greater economy in handling and tends to lower losses incident to removing and replacing the cans. The savings more than pay for themselves in a year.

By studying the daily report sheet and keeping a log of performance, it is an easy matter to discover when the power consumption or the water used or the time required to produce so much ice suddenly changes. The next thing is to find the reason. By studying past seasons' performance, improvements can usually be suggested.

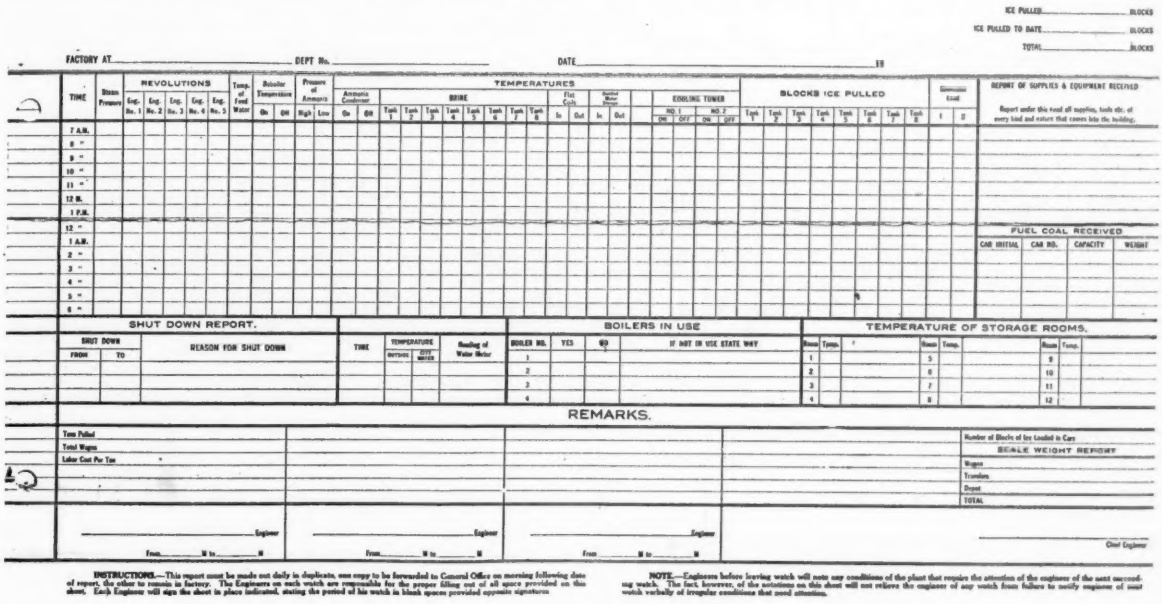


FIG. 8. DESIRABLE FORM OF REPORT SHEET FOR ENGINE-DRIVEN ICE PLANT

Records

It is obviously impossible to maintain uniform performance with any assurance without knowing what is being done and what had previously been done. Hearsay and memory are unreliable and the only way to operate any plant is by means of records.

Adequate records should be complete enough to give the needed information and yet not so complex as needlessly to tax the engineers' time and show how each major phase of refrigeration is being done and so enable the water and power consumed and output realized to be tabulated and based upon a unit basis. Plants differ so widely as to size and procedure that a form of record that is suitable for one plant may not be suitable for another plant. The appended reports cover the salient data required for electrically and steam-driven plants, however.

U. S. Civil Service Commission announces an examination, applications to be rated as received until Aug. 1, for shop apprentice to fill vacancies in the Bureau of Standards, Department of Commerce, Washington, D. C., at $720 a year, and in positions requiring similar qualifications, at this or higher or lower salaries. Appointees whose services are satisfactory may be allowed the temporary increase granted by Congress of $20 a month. Competitors will be rated on physical ability, education, training and experience.

Applicants must have had at least a common-school education and six months' practical experience in the handling of tools as mechanic's helper or as an apprentice; or have attended manual training classes in the eighth grade or high school for at least one year, and must have reached their sixteenth but not their eighteenth birthday on the date of making oath to the application. Age limits do not apply to persons entitled to preference because of military or naval service. Classified employes who have reached the retirement age and have served 15 yr. are entitled to retirement with an annuity. The retirement age for railway mail clerks is 62 yr., for mechanics and postoffice clerks and carriers 65 yr., and for others 70 yr. A deduction of 2½ per cent is made from the monthly salary to provide for this annuity, which will be returned to persons leaving the service before retirement with 4 per cent interest compounded annually.

Apply for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.

Some Faulty Pipe Work

LACK OF GOOD JUDGMENT ON THE PART OF FITTERS OFTEN RESULTS IN AWKWARD PIPE CONNECTIONS. BY H. A. JAHNKE

IN visiting the different power plants, we often notice queer looking pipe jobs in the layout of the plant and in many cases we find that more ells, tees, etc., are used than are really necessary. This not only detracts from the appearance of the layout but it makes unnecessary expense, and much time as well as labor is wasted.

It is the writer's intention to show up some of the faulty pipe work he has seen and how the work could have been done to save material, time and labor.

In doing any pipe work, do not be too hasty about going at it. I have seen pipe fitters and engineers, myself included, start a job, then later on find that they had made the wrong start, as the work would not turn out as they thought it would, making it necessary to tear out some of the pipe and do the work again.

I have found that it is a good plan, before starting on a pipe job, first to make a rough pencil sketch of the layout, as there is more than one way of connecting up a piping system. One way may require more fittings and pipe than another to accomplish the same results; but in first making a sketch of the layout, we many times find the way the job should be started and completed with the least fitting, piping and labor.

A WASTE OF FITTINGS

FIGURE 1 illustrates a bad looking connection from the steam feeder to a radiator, besides one elbow and three nipples less could have been used had the connections been made as shown in Fig. 2.

Figure 3 shows another queer looking pipe layout and I believe the man who did the work tried to see how many fittings he could use on the job. Had the layout been arranged as shown in Fig. 4, two elbows, one tee and a number of nipples less would have been used, and the appearance of the layout would have been much better.

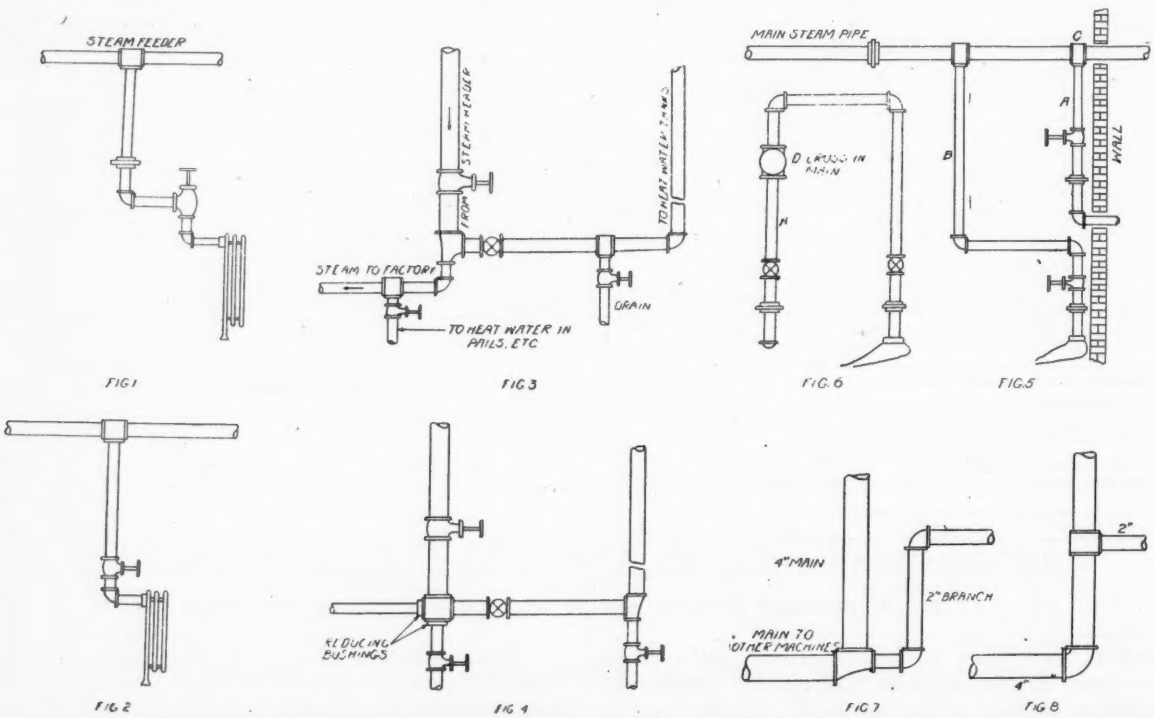


FIG. 1. IMPROPER CONNECTION TO RADIATOR. FIG. 2. PROPER CONNECTION OF RADIATOR SHOWN IN FIG. 1. FIG. 3. IMPROPER PIPE CONNECTIONS REQUIRING THE USE OF TOO MANY FITTINGS. FIG. 4 REARRANGEMENT OF CONNECTIONS SHOWN IN FIG. 3. FIG. 5. AWKWARD PIPING WHICH REQUIRES MORE FITTINGS THAN NECESSARY. FIG. 6. CORRECT ARRANGEMENT OF PIPING SHOWN IN FIG 5. FIG. 7. THESE WATER PIPE CONNECTIONS SHOW POOR JUDGMENT ON PART OF FITTER. FIG. 8. PROPER ARRANGEMENT OF PIPING SHOWN IN FIG. 7.

Figure 5 illustrates another bad layout. It was the pipe fitter's intention to run the 1-in. pipe close to the building wall, but he found that there was a 1-in. branching off from the main steam pipe close to the wall as shown at A, so he cut the main steam pipe, inserted another tee and arranged the pipe so as to bring it close to the wall in order to connect it to the apparatus as shown at B. It would have been much better if the tee, C, had been removed and a cross put in its place as shown in Fig. 6 at D. This would have avoided cutting the main steam pipe and the use of two nipples, as there were unions in the main steam pipes as well as

the 1-in. line a leading through the wall. The appearance of the pipe would have been better, also. Besides, the pipe B made it very inconvenient to get to the top of the boiler, as it was located next to the side boiler wall and it was necessary to crawl along this pipe, thereby running the risk of being burned.

Poor judgment on the part of a pipe fitter is shown in Fig 7. It was necessary to run a 4-in. main water pipe to furnish water to a number of machines in the plant. From this 4-in. main 2-in. branches were run to each machine. As it was not necessary to run the 4-in. main up to the last machine, the fitter arranged the last branch as shown in Fig. 7, which made it necessary to use two ells and two nipples, also more labor than if the layout had been arranged as shown in Fig. 8.

Connecting Branches Into Main Pipes

I HAVE FOUND that in many instances where it is necessary to connect another pipe line into a main steam, water or air pipe, or to make changes otherwise, the pipe fitter breaks into the line to make the connection at the most convenient point, regardless of the appearance of the layout afterward. This is bad practice.

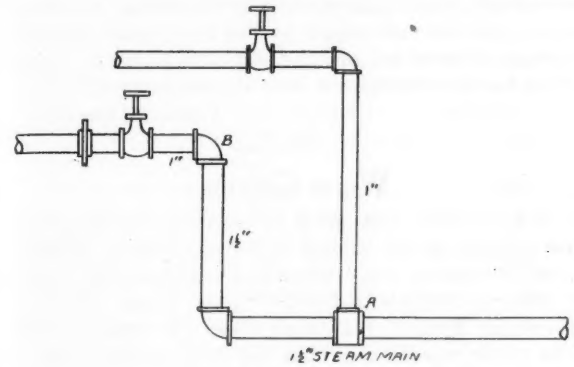


FIG 9

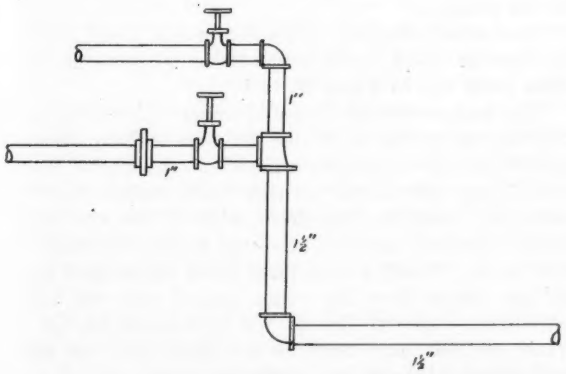


FIG 10

FIG. 9. THIS METHOD OF TAPPING A MAIN STEAM LINE NECESSITATES CUTTING THE LINE

FIG. 10. SIMPLE METHOD OF MAKING TAP SHOWN IN FIG. 9

It is much better, when connecting another branch into a main pipe line or making some changes in the layout, to do this in a workmanlike manner so as not to disfigure the layout. To show how this is done, I relate the following: It was necessary to connect another branch into a main steam pipe. The pipe fitter cut the pipe at a, inserted a tee and ran the branch as shown in Fig. 9. In this case, it would have been much better to have replaced the ell b with a tee, then connected the new branch at this point as shown in Fig. 10. This would have avoided cutting the 2-in. pipe, as all that was necessary was to disconnect the union near the valve in Fig. 9, removing the two nipples, valve and ell, and placing the tee.

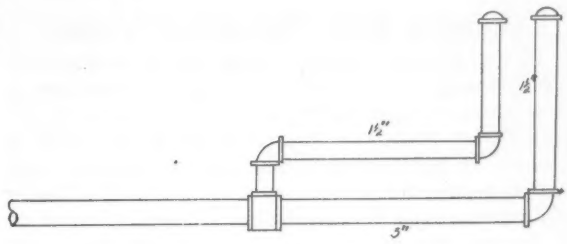


FIG.11

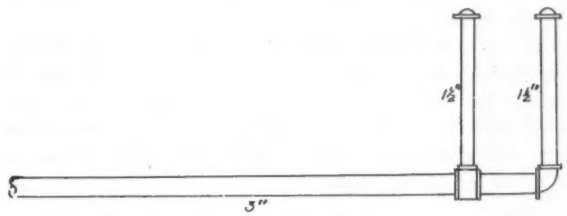


FIG.12

FIG. 11. IMPROPERLY CONNECTED BRANCH

FIG. 12. PROPER CONNECTION OF PIPING SHOWN IN FIG. 11

In another instance, it was necessary to connect another branch into a main water pipe. There was an opening in the main pipe about 8 ft. from the point where the outlet of the branch was supposed to be. To make less labor and a short job, the fitter connected the branch into this opening as shown in Fig. 11. I believe it would have required less labor and less fittings, also less pipe would have been used, had the main pipe been cut and a tee placed where it was wanted, the job then being done as shown in Fig. 12, taking into consideration cutting the two pipes and using two ells as shown in Fig. 11.

TWO NEW EDUCATIONAL motion picture films are announced as being ready for distribution by the United States Bureau of Mines. "A dollar saved is a dollar earned," is the title of a film produced in co-operation with the National Association of Pipe Covering Industries. This film shows the advantages and economy that result when pipes and boilers are properly insulated and the radiation losses are thus overcome. "The story of ingot iron," a three-reel picture showing the various steps in the process of making ingot iron for plates and sheets, was produced in co-operation with the American Rolling Mills Co. of Middletown, Ohio. Requests for the loan of these films should be addressed to the Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

Calculating Boiler Blow-Down Volume

IN THE general routine of boiler house management, it will frequently be necessary for the chief engineer to know to an approximate degree, the extent of his daily boiler blow-down in gallons of water. This is for such purposes as calculating his rate of water evaporation per pound of fuel, and the per cent of boiler horsepower rating he is obtaining; or even to check up his firemen, who may be prone to allow irregular water feeding to occur, with perhaps the resultant need of excessive blowing down in order to bring the water level in the drum back to a point where priming is not apt to occur.

If the water blown down is run into a tank of any description, the problem becomes simply a matter of gaging the depth of water in the tank, before and after blow-down. Then, knowing the surface area of the tank, calculate the resultant cubic feet and gallons of water added to the tank.

BOILER NUMBER _____ DATE_____

Time.	A Amount of blow-down	B Size of boiler drum	Volume (cu.ft.) of blow-down	Gallons of blow-down
	Note: shown in inches	Note: Length − Diam. −	Note: $\frac{A \times B}{12}$ if there is more than one drum to the boiler, multiply by the total number.	Note: A x B x 7.48

FORM FOR RECORDING BLOW-DOWN LOSS

On the other hand, if we are blowing down into the ditch, the simplest method of determining the amount of water lost is to measure the drop on the gage glass; i.e., prior to blowing down, tie a string firmly to the glass at the water level, or daub a paint line here; after blowing down is completed, mark the new level of the water, on the glass; then measure the drop or distance between the two levels on the glass. The next step is to calculate, first the cubic volume, and then the gallons, corresponding to this drop. We can safely regard the volume of water lost in the boiler drum as a rectangular solid. Thus, with a drop of 4 in. and a boiler drum 3 ft. 6 in. in diameter, and 18 ft. long, our volume would be:

$4/12 \times 3.5 \times 18 = 21$ cu. ft. at 7.48 gal. per cu. ft. of water, we have: $21.00 \times 7.48 = 157$ gal. (approximately).

This procedure should be repeated at each blow-down on every boiler, over a period of two to four days, in order to get a fair average figure per boiler per day, or per period of operating, if this be less than a 24-hr. day.

The accompanying form has been found quite useful in recording the preceding data, boiler by boiler.

It is perfectly evident that in calculating the rate of water evaporation per pound of fuel burned, and the per cent of boiler horsepower rating developed, it would be an error to figure the foregoing based on the total volume of water fed to the boilers during the desired period. The water blown down is strictly a loss, since it does not go to make up any of the steam generated. Hence this volume should be deducted from the total amount of water fed, and the evaporation and developed boiler horsepower figured from the resulting difference.

ALLEN F. BREWER.

Worm Gearing

I HAVE READ with much interest the paragraphs in the articles, on Mechanical Features of Motor Installations, by Gordon Fox, Power Plant Engineering, March 1, 1921, and Drives in Limited Space, Power Plant Engineering, April 1, 1921, with respect to worm gearing. Due to the meager data that has been published on the modern straight type of worm gearing, the results that are being obtained with it are not generally appreciated. I would therefore like to add the following information on this subject:

The overall efficiency of the worm and wheel, including bearing losses, runs about 90 to 98 per cent with ratios from 3½ to 1 and 25 to 1.

The modern straight type of worm will reverse with helix angles as low as 10 deg. as evidenced by the fact that 68 per cent of the truck models in the United States and 52 per cent of the British truck models have the worm and wheel for final drive, while 26 per cent of the British pleasure cars also have the worm and wheel for final drive. Nearly all of these truck drives and pleasure car drives have the worm located over the wheel, without any special devices for lubrication except the splash method, and there is no doubt that the worm receives good lubrication, as the mean life of these gears runs well over 200,000 mi.

Worm reduction units are also being manufactured, of which one series has the worm located over the wheel and transmitting loads as high as 200 to 300 hp. without any difficulty with the lubrication. Worm gears may be run as high as 3000 to 4000 ft. per min. on the worm helix path, and quite a few drives running over the above speeds are transmitting over 160 hp. with quite high gear reductions.

Worm gears, like any other gears, must have clearance at the bottom of the teeth or else rotation would be impossible and the bottoming of a worm and wheel would cause a breakage of the gear set.

These gears in mounting only require that the distance between the center line of worm and wheel be kept fairly accurate and that the wheel should be held central over the worm; also a good quality of lubricant must be used in the gear case.

Modern type of worm gearing provides a smooth, quiet, efficient drive and will wear in while other gears wear out; the efficiency actually increases a small percentage after the gears have run under load. The efficiency is also maintained throughout the life of the gear set.

JAMES A. PORTER.

A Superfluous Valve; Cutting in Boilers

ON PAGE 381 of the issue for April 1, H. A. Jahnke advocates a feature that should not be allowed in any steam plant. I refer to the valve in Fig. 3 that is in the exhaust line just below the back-pressure valve. His concluding sentence on this subject is as follows: "It must not be overlooked to open this valve before starting the engine." It is only a question of time, however, before it will be overlooked, and cause more or less trouble. A back-pressure valve is a safety valve, hence it should never be rendered inoperative by making it possible to shut a globe or a gate valve between it and the source of over pressure.

Under the conditions that he mentions, which are very common in practice, 3 lb. back pressure may be sufficient for the day service. The back-pressure valve should be weighted to open at that pressure. Where a reducing valve admits steam to the system to make up deficiencies, it should be adjusted to close at 2½ lb. As a general rule, there is no good reason why more pressure should be carried in the night time than for the day service.

When the engine is started, the reducing valve shuts off some of the live steam. When the engine is shut down, this valve opens wider and maintains a nearly constant pressure. Exhaust steam is worth just as much for heating as live steam, hence there is no good reason for installing the valve that he mentions.

There might be a special case where more pressure is wanted at night. Just add another weight to the back-pressure valve, and make an adjustment on the reducing valve, and it will be secured without introducing a dangerous element. A reducing valve which cannot be readily adjusted for various pressures, is not the best kind.

ON PAGE 334 of the issue for March 15, under the head of Massachusetts Examinations Questions, we are told that it is very dangerous to cut in a boiler when there is a difference of 10 lb. pressure. Why are we frequently given this information? Has anybody ever proved it? Having not found it true in my practice, I am free to admit that if there ever was any trouble along this line, it was due to bad practice in piping rather than to a difference in pressure on two boilers.

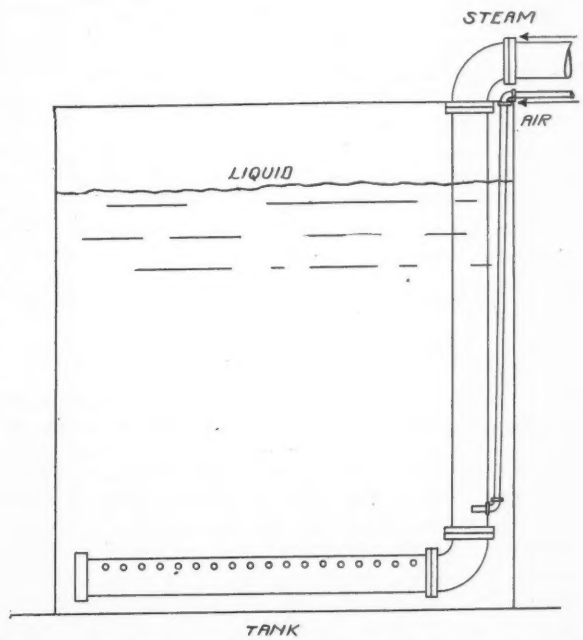
When a certain engineer was taking charge of a plant, he saw the fireman go up on top of the battery of boilers to cut in one that was carrying about 50 lb. less than the others. He cautiously opened the stop valve and steam began to flow into the boiler. The gage showed a steady increase of pressure until it equalled that on the other boilers, and absolutely nothing else happened. The funny part of this story is that the engineer still maintained that such an act was sure to cause disaster, although the fireman claimed that he had done the same thing many times.

Of course it is perfectly safe to have the pressures equal, hence is a measure of safety, and is to be commended accordingly, but that is no reason why it should be hailed as the only permissible way. We turn steam from high-pressure boilers into engine cylinders in which there is only low pressure, and nothing happens. In certain industries, men turn steam at high pressure into digesters, tanks, etc., in which there is no pressure to start with, and bring them up to boiler pressure without accident. As these are practically boilers, as far as this feature is concerned, why can it be dangerous to turn steam into a boiler that is already well heated, although the pressure is 10 lb., or even 50 lb. lower than the other? Will somebody explain and supply proofs?

W. H. WAKEMAN.

Injecting Air With Steam

IN A CERTAIN Western sugar plant, a great deal of heating of water, liquors, syrups and other liquids is done by means of the direct injection of low pressure steam into the body of the liquid. This steam is piped to the bottom of the containing tank, at which point the steam pipe terminates in a number of branches, the branches being perforated with small holes for the escape of the steam into the liquid.



METHOD OF INTRODUCING STEAM AND AIR INTO TANK FOR HEATING LIQUID

Under ordinary circumstances, when steam is thus directly injected into the body of a comparatively cold liquid, a severe vibration is set up which is objectionable from any point of view.

In order to do away with this severe vibration, which is undoubtedly caused by the rapid condensation of the injected steam, the following scheme was tried and found to work satisfactorily.

A ⅜-in. compressed air line was carried along the outside of the steam line, down into the tank, and connected so as to discharge into the steam line at the point of discharge of the low-pressure steam. At this plant, the pressure on the exhaust steam system was 15 lb. gage and the air pressure was about 30 lb.

The scheme worked so well, however, that it was installed in all tanks where heating was done by the direct injection of steam and has given very good results.

CLAUD C. BROWN.

Reading Joints

FIREMEN AND engineers, when applying for a higher license are nearly always shown different types of boiler plate joints and are asked certain questions concerning them. It is therefore essential that the applicant be familiar with such joints and to be able to read them correctly.

Figure 1 shows an end view of a triple-riveted, double butt strap joint, usually designed to have an efficiency of 85 per cent. Sometimes these joints do not show

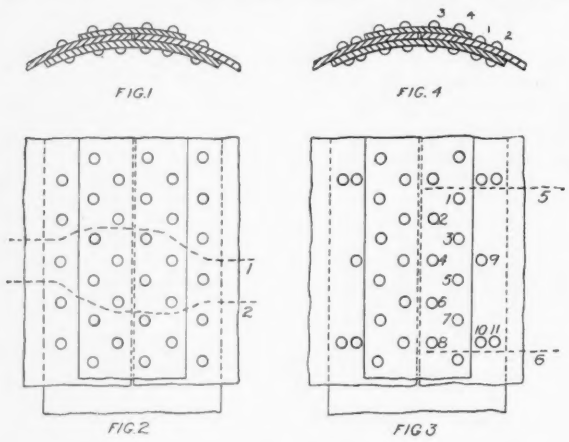


FIG. 1. SECTION THROUGH A TRIPLE-RIVETED, DOUBLE, BUTT STRAP JOINT

FIG. 2. SKETCH OF A TRIPLE-RIVETED, DOUBLE, BUTT STRAP JOINT

FIG. 3. A QUADRUPLE-RIVETED, DOUBLE, BUTT STRAP JOINT

FIG. 4. SECTION THROUGH THE JOINT SHOWN IN FIG. 3.

this efficiency—in some cases they show a higher efficiency. This is due solely to the variations in pitch and diameter of the rivets and the tensile strength of the plate. Rivets may be either in double or in single shear. The joint shown in Fig. 1 has four rivets in double shear and one in single shear. How do we know? In Fig. 2 by drawing the dotted lines 1 and 2 between the outer rows of rivets we find that on each side of the joint there are four rivets extending through three thicknesses of plates. These we say, are in double shear because in pulling apart, the rivet will be cut at two points, while the outer rivet passing through only two thicknesses of boiler plate will be cut at only one point.

The former four rivets in double shear will have a strength of from 1.75 to 1.85 times the shearing strength of the outer rivet which is in single shear, which has a shearing strength of 42,000 lb. per sq. in. of cross-sectional area.

Figure 3 shows a quadruple riveted double butt strap joint, having eight rivets in double and three rivets in single shear, usually designed for an efficiency of 94 to 96 per cent of the original jointless plate. A section of plate is shown between dotted lines 5 and 6. Counting between the lines 5 and 6, 1 to 8 are in double shear and 9, 10 and 11 are in single shear, 1 to 8 going through the outside strap, the boiler plate, and the inside strap, as shown in Fig. 4. Figure 3 differs from Fig. 2 in that Fig. 3 has an extra row of rivets in the outer edge which are sometimes spaced 15 in. apart or twice the distance of the nearest rivets which both are on single shear.

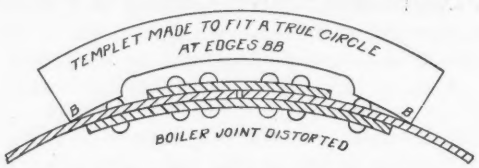


FIG. 5. TEMPLATE METHOD OF TESTING ROUNDNESS OF BOILERS

Joint cracks are almost entirely eliminated in these types, although not entirely, as a small number have been reported, and the cause has been due to the boiler not forming a true circle. This can be shown by placing a template on the outside of boilers that have cracked, the template being made standard to fit a true circle. Figure 5 shows the template, also how it would look when placed on a boiler that did not conform to a true circle. It is obvious that when the boiler contains pressure, it tends to form a true circle as the pressure rises. When the pressure falls the boiler returns to its usual shape. Such a joint, therefore, is subject to constant bending and cracks are inevitable.

A. C. WALDRON.

Investigating Boiler Pitting

IN ENDEAVORING to determine the cause of corrosion or pitting in a boiler, it is best never to try to guess the cause until all the facts are known. Then the cause is known. The pitting mentioned by B. S. G. in the March 15 issue of your paper may be due, as suggested by the insurance inspector, to "too clean" water, which means water of high purity. But it is more probably due to other causes. Only an accurate water analysis will tell the tale.

Many waters are not acid when they enter the boiler, but become so in the boiler because of chemical reactions at high temperatures and high pressures. The determination of the acidity of the feed water and boiler contents is the first step toward finding the trouble.

The type of corrosion is rather a good indicator of the cause of corrosion. For example, general corrosion over the entire surface is indicative of natural acidity, that is, water that is acid when it enters the boiler. When pitting occurs below the water line one suspects sulphuric acid; when it occurs both below and above the water line, hydrochloric acid is probably the cause of the trouble although free acids and dissolved oxygen may be the causes. The free acids are less to be feared than the developed acids, because whereas the latter are easily detected by testing the feed water, the latter may exist unknown until much harm is done.

If the trouble is due to absorbed air, which is commonly the case where returns are collected and used again, the use of soda ash to excess, but not to exceed an excess of about one grain per gallon may be a palliative. A sufficient amount of lime to form a thin scale is another abortive method that can be employed. There are various ways of removing entrained and absorbed air such as the use of air valves on the feed lines immediately outside of the heater; by heating, as most of the air is released above a temperature of 140 deg. F. where dissociation begins; the use of an open heater and sometimes a filter or a tank located well above the suction pump so that the suction head is maintained at all times and the air has opportunity to escape.

Condensed waters are nearly always slightly acid; when make-up water high in oxygen and the free carbonic acid is added, very corrosive effects are often encountered. The addition of a little caustic soda to neutralize the acidity of the water often prevents corrosion. The excess of soda ash should never exceed one grain per gallon. In tackling corrosion problems it is well to remember that corrosion occurs in boilers either (1) because of certain salts in the water or (2) because of the slight acidity of the condensed water or (3) because of gases in the feed water.

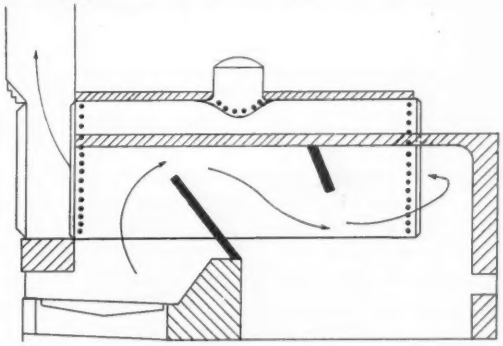
Protective boiler coatings are giving a good account of themselves where they can be properly applied with adequate frequency. The use of zinc plates is another palliative measure, more often employed in marine boilers. Boiler metal consists among other constituents of many minute particles of iron and carbon. These comprise a battery in the presence of an electrolyte. The use of zinc plates results in the zinc being eaten away instead of the boiler metal. A somewhat secondary advantage of zinc plates is that they are more readily oxidizable than is boiler plate, so that they are attacked in preference to the steel by entrained air. Whenever zinc is used, provision should be made to catch the particles of zinc oxide that fall as the plates disintegrate otherwise they may form an adhesive sludge in combination with the organic matter in the boiler water. This may later cause corrosion and overheating of surfaces.

Electrolytic corrosion is sometimes due to dynamic current from generators leaking through the boiler, in which the boiler water constitutes the electrolyte. Such instances are, however, comparatively rare. The use of an oil separator tends to eliminate oil as a probable cause of corrosion; however, many oil separators are failing to give 100 per cent protection against oil either because they have insufficient capacity or else they are not kept in the best condition. In both cases, oil passes into the boiler. An oil separator should not be chosen upon the basis of pipe size used, but upon its ability to treat a definite number of pounds of steam per minute or per hour.

The only way to determine what is the actual cause of the trouble or the combination of causes in proper sequence is to analyze the water at the source, before it enters the heater, before it enters the boiler, the make-up water, the water in the boiler and to examine the feed lines as well as the boiler surfaces. These data will show up conditions that exist—this is a chemist's job, and the job for a good chemist familiar with boiler problems—and so show the way to a remedy. K. RANKIN.

Baffling Fire-Tube Boilers

KINGSLEY L. MARTIN'S excellent article entitled "Recent Practice in Baffling Boilers" in the March 15 number of Power Plant Engineering, causes the writer to believe that it might be possible to increase the efficiency of plain cylindrical or fire-tube boilers by using baffles in a manner similar to that shown by him. If baffles of this kind are a good thing in water-tube boilers, if they increase the efficiency by decreasing the flue gas temperature, the same should also be true for fire-tube boilers. His arguments, according to the writer's viewpoint, are applicable in either case.



SUGGESTED ARRANGEMENT OF BAFFLES IN RETURN TUBULAR BOILER

The accompanying sketch shows how this could be accomplished by interposing two slanted baffles. These would cause the hot gases to follow a zigzag path and cool off considerably before entering the return flues. The flues, then, would cool the gases still further and give us the desired higher efficiency. As far as the writer knows, this method has not been used with plain cylindrical boilers or return tubular boilers. If it has been used and if any of the readers of Power Plant Engineering have had experience with such boilers, information on the results would be interesting and doubtless of much value. N. G. NEAR.

Why the Boiler Would Not Steam

WHEN I was a small boy, my father used to call my attention to the fact that "cleanliness was next to godliness." So in my life's work I have made it a point to keep this motto in mind and to live up to it.

Personally, I feel that cleanliness is something that affects us mentally, morally and physically. My experience is that a clean man is clean in every way and he will endeavor to have his surroundings accordingly.

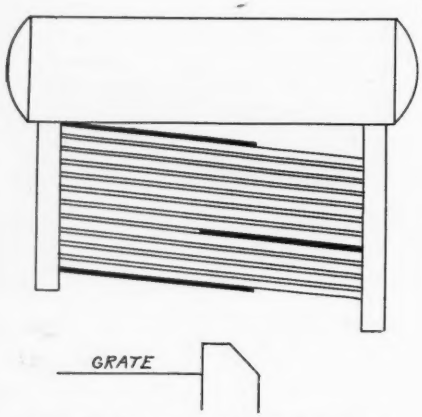
My business takes me into a great many steam plants and I have found that in plants where the chief engineer dresses to his job I have no work to do. Everything is as it should be.

I recently visited a small plant in which considerable trouble had been experienced with a new boiler. This trouble in brief might be called inefficiency in so much that the boiler failed to make steam. I knew that poor operating conditions were directly to blame and without looking the plant over I informed the engineer, much to his indignation, that this was the trouble with his boiler.

One look in the chief's office was enough for me. Dirty clothes, old magazines, broken tools, odd bits of

waste and packings, etc., were all piled over the place. The desk was not accessible for work and the floor was a mass of grease, dirt and spit. Could a competent engineer work in such surroundings?

I asked my chief the particular trouble with this boiler and he unfolded a long tale of woe. It seems that this boiler was installed with a new layout of baffling, which, I assume, was more or less of an experiment. The boiler is of the horizontal water-tube type. Baffling is of the horizontal type laid out as illustrated. The engineer's contention was that the gases were retarded in their path from the combustion chamber, due to the many turns in the path from the fire to the stack.

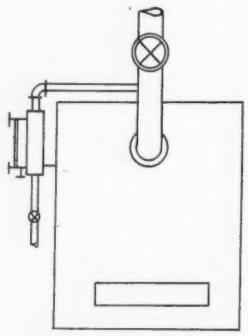


ARRANGEMENT OF BOILER BAFFLING

A few days after this, I was not surprised to hear that the builders of the boiler had run a test and that they had an evaporation of 10 lb. of water per pound of coal, which any engineer will admit is good steaming qualities in any boiler. One thing that the builders showed was that cleanliness is absolutely essential if steam is to be made in a boiler. A. D. PALMER.

Cause of Leaky Tubes

THE SKETCH illustrates a vertical boiler that has been operating about 7 mo. and up to the present time no orders have come to make a change in the connection. The law states that the water column shall be directly connected to the boiler. The top connection from the column is to the 3-in. steam outlet, and while this boiler is not operated up to capacity, very little difference in the water level is noticed. I know of several boilers of this type connected the same way.



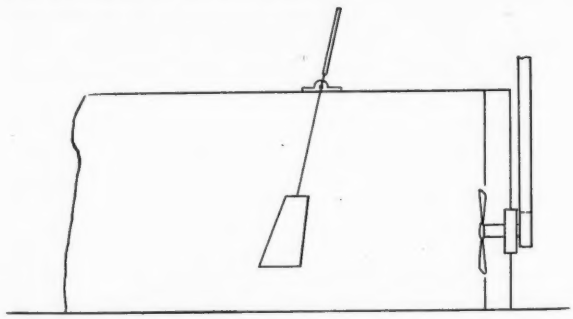
INCORRECT AND POSSIBLY DANGEROUS WATER COLUMN CONNECTION

Most of these boilers have given trouble from leaky tubes, and it has been considered that the boilers were not properly fired. The greatest trouble is that they operate 24 hr. a day seven days a week and to wash them out they cool them down as quickly as possible, causing contraction strains, and the feed water enters about 4 in. above the flue sheet, another cause for strains, for when the water level is low cold water is turned upon hot sheet and causes the tubes to leak. Take a hot boiler with cold water of about 35 to 40 deg. F. in winter time means a sudden contraction.

Why blame anybody for leaky tubes if such conditions exist? FRED W. SCHNEIDER.

Telltale on Brine Tank Agitator

IN AN ICE PLANT with which the writer was connected some time ago, considerable trouble was experienced with an old belt-driven agitator on one of the large brine tanks, for it frequently happened that the agitator "went bad" or the belt slipped off, or loosened up so much that practically no power was being transmitted, with the result that the freezing time in the tank was increased by several hours.

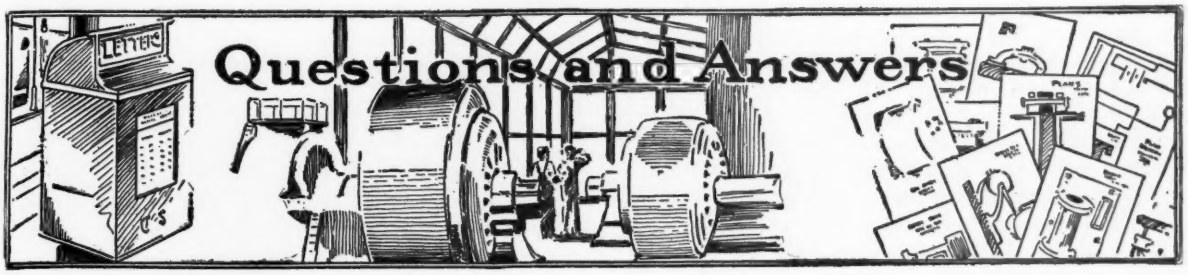


ARRANGEMENT OF TELLTALE

The tank happened to be the rear one in a large room made up of several tank units. One of the operating men after being detailed to keep watch on the tank, rigged up a telltale device as illustrated. Whenever the agitation was good, the white strip at the top end of the rod carrying the plate leaned toward the right about 30 deg.; as the agitation decreased, the white strip tended towards the vertical, serving notice on the employes in any part of the plant of the room that the agitator needed attention. M. A. SALLER.

U. S. CIVIL SERVICE COMMISSION announces examinations (receipt of applications to close May 17) as follows: (1) Engineer Draftsman, $1500 to $2100 a year; (2) Mechanical Engineer, $3000; (3) Mechanical Draftsman, Patent Office, $1000. (Appointees whose services are satisfactory may be allowed the increase granted by Congress of $20 a month.) Entrance salaries may be higher or lower than those stated above, for certain positions.

Apply for Form 1312, stating examination title, to the Civil Service Commission, Washington, D. C.



Piston Valve Engine Problem

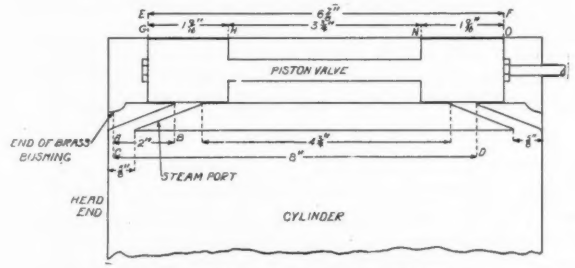
APPLICANTS for second and third grade engineers' license are frequently asked various questions regarding piston valve engines. This article is submitted with the thought that it may be of interest to some of the readers of Power Plant Engineering to work out the problems given.

We have in our plant a Sturtevant engine with a direct-connected piston valve taking steam on the inside.

The diameter of engine cylinder is 6 in.; length of stroke, 8 in.; diameter of piston valve, 3 in.; and the valve travel is $2\frac{11}{16}$ in.

A Waters throttling governor is used. The diameter of the governor pulley is $5\frac{1}{2}$ in., diameter of pulley on crankshaft is $5\frac{1}{4}$ in. Speed of governor is 325 r.p.m. The valve travels inside of a brass sleeve or bushing.

In overhauling this engine, the valve was removed and measurements taken, as shown in the sketch.



VALVE CHEST AND PISTON VALVE

Referring to the drawing, A, from which the measurements are taken, is the end of the bushing.

It was found that when the valve eccentric was at its extreme travel on the crank end, the distance from the end of the bushing to the end of the valve was $2\frac{3}{8}$ in. And when the valve eccentric was at its extreme travel on the head end, the valve projected through the bushing $\frac{5}{16}$ in.

At what speed was the engine designed to run? What is the amount of steam and exhaust lap? Is the valve set right, and if not, how would you adjust it?

E. C. W.

Boiler Seams; Leaky Piston; Valve Installation

ARE YOU ABLE to answer any or all the questions here submitted? Let's hear your opinion as to what's what or what isn't.

1. Can a butt constructed seam be used on the furnace plates of an internally fired boiler?

2. How may a test be made for a leak past the piston or inside packed plunger of a water pump?

3. In placing a globe valve on a feed-water line to a boiler, should the pump deliver under or on top of the disc?

Ice Cream Hardening Room

COULD I get some information on direct expansion rooms? I have one room 4 by 6 by 8 ft. with 300 lineal feet of $1\frac{1}{4}$-in. pipe. I can pull the temperature down to zero in 30 min., but cannot get it below zero. If I carry over 2 lb. back pressure on my machine, the temperature will rise in the room. I would appreciate it very much if you could tell me where the trouble lies. Could it be possible that there is not enough piping in the room? This room is for ice cream.

A. The trouble is not owing to the amount of piping in the room. Three hundred lineal feet of $1\frac{1}{4}$-in. pipe in an ice cream hardening room of that size is sufficient to take care of the heat leakage into the room and also handle about 120 gal. of ice cream every 24 hr. If more than 120 gal. are hardened per day, the 300 ft. of pipe is not enough.

To make this readily understood, details must be looked into.

A room 4 by 6 by 8 ft. will contain 192 cu. ft. space. The walls, floor and ceiling will have an exposed area of 208 sq. ft.

Allowing for fairly good insulation, the heat leakage into the room will be at the rate of 2 B.t.u. per sq. ft. of surface for each degree temperature difference per 24 hr. The average temperature difference will be about 80 deg. if the room is held at zero.

Then $208 \times 2 \times 80 = 33{,}280$ B.t.u. Now we must add 20 per cent to take care of the heat entering through open doors, lights and workmen. Adding this, brings the total heat to 39,936 B.t.u. This is the actual amount of heat to be dealt with before considering the cream to be hardened; 300 lineal feet of $1\frac{1}{4}$-in. pipe contain about 135 sq. ft. surface. The exchange of heat from the air in a still air hardening room to the ammonia in the direct expansion coil will be at the rate of 2 B.t.u. per sq. ft. pipe surface per degree temperature difference per hour.

With a back pressure of 2 lb. the temperature of the ammonia in the coils will be about 23 deg. below zero. This gives a temperature difference of 23 deg. Then $135 \times 2 \times 23 \times 24 = 197{,}040$ B.t.u. which is the amount of heat possible to take up with the ammonia evaporating in 300 lineal feet of $1\frac{1}{4}$-in. pipe under the given conditions. Frost on the coil or oil in the coil will reduce this figure, depending on the degree of insulating effect. There is also a loss due to the cooling of the liquid ammonia to the temperature of the evaporating coil. To keep this loss as low as possible

care must be taken to deliver the liquid to the expansion valves as cold as the coolest water available will make it.

Under ordinary operating conditions the total loss will be about 25 per cent. This lowers the figure to 147,780 B.t.u.

Now 147,780 — 39,936 = 107,844 B.t.u. which is the amount of heat possible to take up from the ice cream that is put into the room for hardening.

As a general rule, it requires about 900 B.t.u. for each gallon of ice cream hardened. Then 107,844 ÷ 900 = 120 gal. approximately. This is the number of gallons of ice cream that can be handled in this room.

Look into the condition of the insulation of all the walls, floor and ceiling. See that the doors are the kind that are made for low temperature freezers and that they fit properly.

Test the back pressure gage so as to be sure it is true. Gages that are not correct are misleading and will cause loss in capacity of the plant.

Pay close attention to the gage glass on the liquid receiver and see that the ammonia shows in the glass at all times. When the temperature in the hardening room gets down to zero, some of the ammonia may "hide out" and by so doing reduce the charge so as to allow gas to pass directly from the condenser to the evaporating coils. A. G. Solomon.

Engineers Examination Questions

1. What do you mean by the term, "a one-horsepower boiler"?

2. Is there no more definite rating than this for the horsepower of boilers?

3. Does the horsepower of steam boilers calculated according to this rule come near the actual consumption in condensing engines?

4. In choosing a boiler how would you determine the proper size, basing the horsepower on the rating?

5. Is there any disadvantage in using a boiler larger than is strictly necessary to evaporate the required amount of water?

6. What horsepower would you use for the following kinds of engines running condensing and non-condensing?

(A) High-speed, automatic cutoff, 100 hp.
(B) Plain slide-valve throttling governor, 100 hp.
(C) Corliss type, 125 hp.
(D) Compound Corliss type, 200 hp.

7. Can a boiler of a given size evaporate as many pounds of water per hour to a pressure of 100 lb. as to a pressure of 70 lb.?

8. Upon what does the grate-surface of stationary boilers depend?

9. How many pounds of coal can be consumed per sq. ft. of grate surface per hour?

10. What do you mean by heating surface?

11. Give us a rule by which you would calculate the heating surface of a cylinder boiler, also the horsepower of boiler.

12. How much heating surface per horsepower is provided in fire-tube, and water-tube boilers?

13. Can you thus calculate approximately the horsepower of any boiler?

14. What is the average ratio between the grate surface and heating surface of stationary boilers?

15. What kinds of sediment does boiler feed water usually contain?

16. What is the cause of smoke? (a) How can it be prevented?

Answers

One horsepower is equivalent to the evaporation of 34½ lb. of water from and at 212 deg. F. per hr. Hence a one-horsepower boiler is one that will evaporate this quantity of water per hour.

2. Water-tube boilers are usually rated at 10 sq. ft. of heating surface per boiler horsepower. This is an arbitrary standard, however, and is not as accurate as the first rating.

3. There is no rational connection between the horsepower of a boiler and that of the engine which it supplies. A boiler horsepower, as stated in question 1, is the evaporation of 34½ lb. of water from and at 212 deg. F. containing 970.6 B.t.u. per lb., which is equivalent to 33,479 B.t.u. per hr. On the other hand, an engine horsepower is 2546 B.t.u. per hr., which is about 7.7 per cent of the boiler horsepower. The original basis for computing the boiler horsepower was determined from an engine with a water rate of about 60 lb. In this case, the horsepower of the boiler and that of the engine are somewhere near equal.

4. In choosing a boiler, its size should be determined by the steam consumption of the engine. If an engine uses, for instance, 20 lb. of steam per horsepower, the boiler will have to supply that much steam and the rating would be 20 ÷ 34½ times the rating of the engine.

5. If a boiler is larger than it actually needs to be for the service at hand, it will naturally not be working at capacity and its efficiency will be lowered.

6. Boiler capacity necessary to supply an engine depends, as stated before, on its water rate. (A) A high-speed, automatic cutoff, 100-hp. engine has a water rate running condensing of about 22½ lb. per hp.-hr. The boiler capacity necessary would be 22½ ÷ 34½ × 100 = 65 hp. This same engine running non-condensing would have a water rate of 29 lb. per hr. and the corresponding boiler horsepower would be 29 ÷ 34½ = 98 hp. (B) For a plain slide-valve, throttling governor, 100-hp. engine, the water rates, condensing and non-condensing, are about 19½ and 25 lb. respectively. The boiler horsepower necessary in this case would be 19½ ÷ 34½ × 100 = 56½ hp., or, non-condensing, 25 ÷ 34½ × 100 = 72½ hp. (C) A Corliss type, 125-hp. engine has a water rate condensing of 16½ lb. and non-condensing 21 lb. The corresponding boiler capacity would be 16 ÷ 34½ × 125 = 60 hp., and 21 ÷ 34½ × 125 = 76½ hp. (D) A compound Corliss engine of 200 hp. would have a water rate of about 14½ lb. condensing and 18¼ non-condensing. The boiler horsepower necessary would be, condensing, 14¼ ÷ 34½ × 200 = 83 hp., and non-condensing, 18¼ ÷ 34½ × 200 = 106 hp.

7. A boiler of given size with the same combustion conditions cannot evaporate as many pounds of water per hour to a pressure of 100 lb. as it can to a pressure of only 70 lb.

8. The area of the grate surface of a stationary boiler depends on the kind of coal used, the thickness

of fire, the draft available, and the kind of stoking employed.

9. The pounds of coal that can be consumed per square foot of grate surface per hour varies in different installations from as low as 3½ lb. to 41 lb. and even reaches the high mark of 225 lb. in locomotive practice. This, again, depends on the kind of coal used, the draft, and the kind of stoking.

10. The heating surface of a boiler is that part of the tubes and boiler shells which is exposed to the heat of the combustion gases.

11. The heating surface of a horizontal return tubular boiler is composed of a tube surface and a shell surface. The extent of the tube surface is equal to the circumference of the tube in feet, times its length, times the number of tubes. The shell surface is equal to half the circumference of the shell in feet times its length.

12. Water tube boilers are usually rated at 10 sq. ft. per hp.; return tubular boilers are usually figured at 12 sq. ft.

13. By knowing the heating surface of any boiler you can thus approximate the horsepower.

14. There is no rational relation between the grate surface and the heating surface of a boiler; however, for hand-fired setting using bituminous coal, the ratio is usually about one to sixty grate surface to heating surface with natural draft. For anthracite coal, stokered firing, or forced draft, this ratio would be increased.

15. Boiler feed water usually contains calcium and magnesium bi-carbonates and sulphates. There are numerous other precipitates that form, but these are the most common.

16. Unconsumed carbon resulting from an insufficient air supply is the usual cause of smoke. It can be prevented by using more air or obtaining a better mixture of air and fuel or providing a longer passage in which combustion can be completed before striking the heating surface of the boiler.

(To be continued)

Color Scheme for Pipe Lines

WE UNDERSTAND that the A. S. M. E. have a color scheme for distinguishing the various power-plant pipe lines, but are unable to locate any definite information on this subject. W. O. B.

A. The scheme for the identification of pipes by colors, as proposed by the American Society of Mechanical Engineers' committee on the identification of power house piping, appeared in the transactions of that society in 1911, volume 3, page 176. In substance, this recommendation reads as follows:

"In the main engine room of plants which are well lighted and where the functions of the exposed pipes are obvious, all pipes are to be painted to conform to the color scheme of the room, and if it is desirable to distinguish pipe systems, colors are to be used only on flanges and valve-fitting flanges. In all other parts of the plants, such as the boiler house, basement, etc., all pipes (exclusive of valves, flanges and fittings), except the fire system, are to be painted black or some other single, plain, durable, inexpensive color.

"All fire lines (suction and discharge) including pipe lines, valve flanges and fittings, are to be painted red throughout. The edges of all flanges, fittings or valve flanges on pipe lines larger than 4 in. inside diameter and the entire fittings, valves and flanges on lines 4 in. inside diameter and smaller, are to be painted the following distinguishing colors, numbered 1 to 12 inclusive:

Steam division	1. High pressure—white.
	2. Exhaust system—buff.
Water division	3. Fresh water, low pressure—blue.
	4. Fresh water, high pressure boiler-feed lines—blue and white.
	5. Salt water piping—green.
Oil division	6. Delivery and discharge—brass or bronze yellow.
Pneumatic division	7. All pipes—gray.
Gas division	8. City lighting service—aluminum.
	9. Gasoline service—black; red flanges.
Fuel oil division	10. All piping—black.
Refrigerating system	11. White and green stripes alternately painted on flanges and fittings, body of pipe being black.
Electric lines and feeders	12. Black and red stripes alternately on flanges and fittings, body of pipe being black."

Excessive Ebulition in Boiler

WE HAVE one 440-hp. B. & W. boiler working under a pressure of 150 lb. gage. There are two 4½-in. safety valves, one on each drum. When the boiler blows off, the water lifts to the top of the gage glass and stays there till the boiler stops blowing. Then the water settles back. What causes this and what can be done to stop it?

G. W. C.

A. There are several reasons why the water in your boiler rises to the top of the glass when both safety valves are blowing, returning to normal level when the pressure it relieved. A combination of two or more of these would cause you trouble and removing the cause will remove the trouble considerably.

Feed water containing vegetable matter, or condensate from heating or surface condensing systems containing a trace of oil will foam easily, and especially so if the steam be suddenly withdrawn from the boiler either through the safety valves or for power or industrial purposes. A sudden withdrawing of the steam naturally reduces the pressure slightly when a more rapid ebulition (or boiling) of the water is set up and as the globules of steam arise rapidly to the surface they naturally cause the water to be held in suspension, causing a rise in the water level about in proportion to the demand for steam.

Frequently in marine boilers, the water level will rise considerably when "handling" the engines and "full speed" is called for intermittently for a few revolutions.

It might be also that your water column is located too high with reference to the drums and thus the usual gage or two gages of water will actually indicate a higher water level in the drums than should be. On your type of boiler, the drums are comparatively small in diameter which at best gives a somewhat restricted evaporative area at or near the center level of the drum.

If the water level be carried several inches higher, this area will be still further restricted which becomes quite aggravated when sudden demands are made on the boiler for steam.

It seems that your safety valves are plenty large for your boiler according to recognized rules. In fact, two 4-in. valves will relieve your boilers under all conditions, although it is better to have any errors as to size too large rather than too small.

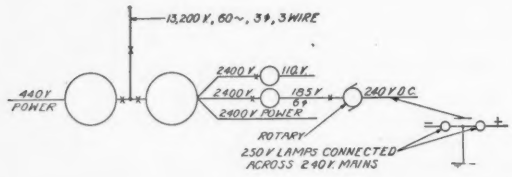
Since both valves are connected to the same steam space, you can relieve the situation a great deal by setting one valve to blow, say, a pound or two ahead of the other. Then if you look into the water level, as suggested above, you may be able to carry a lower level with absolute safety and thus secure not only a larger evaporative area but a large steam space, which is equally essential.

As to your feed water, you can determine better than anybody else whether it contains anything that will cause foaming or priming, and if so, use the proper separating or filtering devices to secure the desired results.

GEORGE H. WALLACE.

Grounded System

WE HAVE had considerable trouble with the ground lamps on our switchboard burning out. These lamps are connected across the 240 v. d. c. bus bars of the system shown in the accompanying sketch. With the voltmeter showing the proper voltage the lamps will burn at their proper voltage across the bus.



SHOWING RELATION OF THE 240-V. D. C. CIRCUIT TO THE SYSTEM

When a heavy ground occurs on the line it will blow the lamps up, sockets and all. At times it will hold the lamps white hot for an hour and at other times they will blow out instantly. The lamps burn out not only in the power house but all over the system unless we use four, 250-v. lamps, two in series, on the 240-v. circuit.

H. S.

A. Without the opportunity of making an investigation of the problem confronting you, it is impossible to arrive at any definite conclusion regarding your difficulty and its proper solution.

Undoubtedly the 13,200-v. system supplying you with power is permanently grounded and it is obvious, therefore, that if another ground exists at any point on your system, this will readily manifest itself. It is our opinion, based upon your statement, that two 250-v. lamps connected in series are required for the purpose of testing for this ground that the rest of your trouble is on your 440-v. power systems and it is our suggestion that you disconnect this from its source of energy supply and test it out for ground.

In spite of any ground which may exist on the system—under the assumption, however, that such a ground does not directly or indirectly form an absolute short circuit—any lamp of proper voltage rating connected across the bus bars should light up only to correct brilliancy.

The Why of the Receiver

WHY IS A receiver placed between a high and low-pressure cylinder on a cross-compound engine, with the cranks set 90 deg. apart?

W. S. A.

On a cross-compound engine with cranks at 90 deg., the low-pressure steam port opens when the high-pressure cylinder is in the middle of the exhaust stroke.

From the time the higher pressure release begins, until the middle of the stroke, there is consequently pressure being built up in the passage between the two cylinders. If the low-pressure cutoff occurs before the half stroke, there is also an accumulation of pressure from the low-pressure cutoff to the high pressure of compression, which, for quarter cutoff, would be one-fourth of the stroke, and for one-third cutoff would be one-sixth.

It will be seen that there is a compression, then, between the two cylinders for approximately three-quarters of the stroke. If there were no receiver capacity here, the pressure would increase beyond that ordinarily allowed.

In order to give a good diagram, the receiver pressure should be as nearly constant as possible. For this purpose, most receivers are proportioned to have a volume from one to one-and-a-half times that of a high-pressure cylinder.

Sealing Leaks in Concrete

IS THERE any preparation to stop leaks in a concreted cellar which is used to supply water for a reservoir?

J. G. L.

A. Sodium silicate, commonly known as water glass, is often used in making concrete walls impervious and sanitary.

The surface of the walls should be made as smooth as possible by chipping off any projection made by the joints between the boards. Then, to remove the dirt and dust, wash the surface with clear water. This should be done during the dry season, so the walls will dry before applying the water glass. To one part of water glass add five parts of water. Apply the solution with a brush and after 4 to 6 hr. give it another coat. If the tunnel is dusty, the surface should be washed off and allowed to dry before applying another coat. Repeat the process with four coats, not allowing the time between applications to exceed 24 hr. It is said that the surface forms into a hard and insoluble scale.

Another scheme in use employs a solution of zinc sulphate for stopping up the pores. Make a solution

containing 8¾ lb. of zinc sulphate to a gallon of water and paint the concrete with this mixture. The zinc sulphate will act on the lime in the concrete forming insoluble calcium sulphate and zinc hydroxide which will fill up the minute holes and pores in the concrete.

After painting the concrete with this solution, let it dry about 100 hr. and after thoroughly dry, brush the walls with a wire brush, being sure to have it clean, dry and reasonably free from dust. Give the walls two goods coats of some waterproof cement and finish up with a light coat of tar or asphaltum.

Computation of Heating of Coal from the Ultimate Analysis

How would you compute, by Dulong's formula, the heating value of a coal whose analysis is carbon 75.49 per cent, ash and moisture 14.9 per cent, hydrogen 3.78 per cent, oxygen 4.15 per cent, and sulphur 1.68 per cent? C. L.

A. According to Dulong's formula, the heating value of coal can be determined from the following relation:

$$h = 14{,}600\ C + 62{,}000\ (H - O \div 8) + 4000\ S$$

where C, H, O, and S are the proportions, respectively, of coal, hydrogen, oxygen and sulphur in fuel.

Substituting the values you have given me, we get:

$$h = 14{,}600 \times 0.7945 + 62{,}000 \times (0.0378 - 0.0415 \div 8) + 4000 \times 0.0168$$

which equals 13,692 B.t.u.

Capacity of Coal Piles

Will you please give me a rule for getting an estimate of the number of tons of coal in a pile unloaded by hand along a track? R. L. B.

A. To find the volume of a coal pile, we give you the following equation, which was taken from page 604, of the July 15, 1917, issue of Power Plant Engineering:

$$\text{Tons} = 0.004{,}737\ W^2\ (L - 0.4764\ W)$$

where W equals the width of the pile, and L, the length.

This equation is for ordinary steaming coals and it takes into account the angle of repose. The pile is supposed to be formed to an edge on top.

Corrections for Vacuum Readings

I cannot understand the reason why vacuum gage readings are corrected to a 30-in. barometer; take for an example a mercury column which reads 28-in. vacuum and the barometer reads 29.50, 28 in. of vacuum corrected to 30-in. barometer would be 30 — 29.50 = 0.50. The vacuum is then 28 + 0.5 = 28.5 in. The point I cannot understand is, why there is more vacuum after the vacuum gage reading has been corrected to a 30-in. barometer than there was before being corrected. Why is this done and of what value is it? E. V. B.

A. The important thing in dealing with a vacuum is the absolute back pressure. To give a vacuum reading in inches of mercury without knowing the barometer is meaningless. A 25-in. vacuum in Denver, for instance, is impossible. When a vacuum is designated, it is usually assumed to refer to a standard barometer of 29.92 in. Thus, a 28-in. vacuum with the barometer at 29.5 is 1½ in. absolute pressure. A 1½ in. absolute pressure in connection with a 29.92-in. barometer would be 28.42-in. vacuum. Thus, a 28-in. vacuum under these actual conditions is equivalent to a 28.42-in. vacuum for standard conditions, and in speaking of this vacuum the latter figure would be used.

Reducing Grate Area

H. F. W. concludes his inquiry in the April 1 issue of Power Plant Engineering, under the above heading, by stating: "I cannot see any engineering principle which would prohibit reducing the grate to the same proportion as the capacity of the boiler is cut down."

On one occasion, I had a similar proposition. A small boiler was under consideration, and feeling as H. F. W. stated above, I ordered them to reduce the grate area in the same proportion as the load was reduced; that is, by extending the bridge wall forward above the grates so as to leave the required grate area. To my great surprise, I was informed that the result was not satisfactory, and that the fireman was very much dissatisfied. This brought out the importance of the fireman, and I made a visit to the plant to see what merits the fireman's protest had, if any. He simply opened the fire doors and pointed out the fact that the available grate areas remaining were 1 ft. long and 4.5 ft. wide, which made it difficult to maintain a fire. He suggested reducing the grate area in such a way as to give him a chance to fire, and in this case, the reduction was made from two sides and there was no more complaint.

In the case of H. F. W., a grate area, say, of 25 sq. ft. would be ample, and the grate reduced to 5 by 5 would give the desired result. Figures, no doubt, can be depended upon to tell the truth, but they must be used with discretion. H. Misostow.

Drop in Vacuum

I would say in answer to E. D. J.'s question, which appeared on page 295 of the March 1 issue of Power Plant Engineering, that a leak in the suction line where there is a low water supply would cause his pumps to act as they do. It may also be that the plungers or pistons of these pumps are leaky so that in speeding up they do not pick up enough water at first, which would cause a falling off the water supply and consequently a drop in vacuum in the condenser. D. G. S.

Length of Water Columns

Referring to the issue of Power Plant Engineering for April 1, 1921, page 394, regarding water columns, I wish to take issue with J. E. Noble. He says it is poor practice to carry a high water level. He is right as far as the standard run of stationary boilers is concerned; but on a Scotch marine boiler it is somewhat different.

I once had a single furnace boiler of the Scotch, or, more properly, the Clyde type in a furniture plant. It furnished the steam for a slide-valve engine located about 45 ft. away. Let the water in this boiler get down to one-half glass and the steam goes down also. So I used to carry the water within about 2 in. of the top, and the steam was always up. The column was set 2 in. above the tubes and connected to the boiler according to the A. S. M. E. rules. R. G. Summers.

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Power Plant Developments in Sight

Through the haze of doubt as to the outcome of the industrial conditions as they exist today there are a few rays of light which, we believe, point to a development in the power plant field which will be greater than any which has heretofore been experienced. Before this can happen, however, a great many barriers must be removed, some of which are financial, others engineering, and still others, social and political. It behooves those in the industry, however, to prepare the way. No man knows just what the future has in store for him but it is a pretty safe guess that the thing he wants will not come his way unless he prepares to receive it, mentally, physically and financially.

Unfortunately there are prevailing among many industries conditions which are extremely bad, nobody is buying, factories working only part time, thousands of men out of work, yet, however true this may be for other industries, statistics and reports do not indicate that the power plant industry has suffered from lack of demand for power or that development of new projects has ceased, but on the contrary development work in the past year has shown a tendency to increase with much more in prospect.

Looking over the U. S. Geological Survey reports for the two years ending Feb. 1, 1921, we find a substantial increase of nearly 15 per cent in the power production of public utility plants in the United States during 1920 over 1919 with the exception of the months of November and December when the load curve for 1919 crosses over that for 1920, and even then the lowest points in production for 1920 and 1921 (May and January) were exceeded only in November and December of 1919. These facts certainly cannot be interpreted as indicative of anything like a severe slump in demand for power, particularly when it is known that many central stations are loaded to their full capacity and are contemplating improvements which will give added capacity.

As to the future outlook we have only to watch the daily press to note that in all sections of the country construction work is either going on, actual plans are being made or the preliminary steps have been taken to secure sites, water rights, franchises and other legal necessities. We could quote statements from all parts of the country showing that many millions of dollars are to be spent within a comparatively short time for power plant development.

The Federal Power Commission has received 210 applications for permits or licenses to develop water power sites which if carried to completion would cost in the neighborhood of $4,000,000,000 for power plants and transmission lines. These of course are merely plans, the aggregate of which would be about 14,000,000 hp., thus increasing the installed horsepower of the country by about 35 per cent, the realization of which can hardly be expected for some years to come; but with the financial interests of the country in the mood to start development work so as to keep ahead of the demand for power, there is every reason for optimism in the power plant field.

It is only in the industrial field that any of the power plants of the country are shut down at all and

in nearly all of these cases the shutdown was due, owing to the fact that improvements and repairs are necessary after the strenuous efforts to supply all the power needed up to the time of the curtailment of output about a year ago. In these plants this is the time to get all equipment tuned to the highest point of efficiency for it is more than likely that competition will be strong and every dollar saved in the power plant will be an aid to the owner.

The engineers who are prepared by training and experience to operate power plants at their highest efficiency and economy, the manufacturers of power plant equipment whose products will give highest efficiency and reliability, and the engineering concerns that can show records for designing and constructing the most successful power plants, will all have an opportunity to take an important part in the industry of the country and those who are wise are now preparing in every way possible for the demands and responsibilities that will be placed upon them in the not far distant future.

Off Duty

The time-worn proverb, that "There is no new thing under the sun" probably retains as much truth today as it did when first formulated ages ago by King Solomon, but, like other proverbs, is often misinterpreted and, to use another trite expression, must be taken with a grain of salt.

There are many new things under the sun today, regardless of any significance to the contrary conveyed by the proverb. For instance, when the new Lafayette high-powered radio station in France was recently completed and formally turned over to the French Government on Dec. 18, 1920, old Sol had never before been able to direct his rays on anything that could equal it. It was fully twice as powerful as any other station in existence.

Of course, it may be argued that wireless telegraphy is not new and that, therefore, old Sol was looking down on something that was ancient centuries before Chris. Columbus crossed the pond, but such reasoning only evades the issue. Without doubt, the earliest savages employed a system of wireless telegraphy when they signalled from one hilltop to another by means of smoke or fire, but then, we may as well argue that even they were preceded in the art by the first human beings that carried on audible or visible conversation; for what is conversation but a method of conveying intelligence without wires?

These, however, are small points and we may safely conclude that wireless telegraphy is an invention of the past 25 yr. While the first practical system of wireless telegraphy was invented by Marconi in 1896, the idea of establishing communication between two points on the earth's surface without wires had long occupied the minds of inventors. Various methods had been tried out which were based on a number of different electrical and magnetic principles, but none of them were successful over distances exceeding a few yards.

It was not until Maxwell enunciated his famous electromagnetic theory of light that a new era of scientific investigation opened up. Hertz's discoveries and investigations published in 1888 cast a flood of light upon Maxwell's theory and placed into the hands of young Marconi, then a student at the Leghorn Technical School, the principles upon which he subsequently based his system of wireless telegraphy. To these three scientists, then, belongs the honor of giving to the world one of the most stupendous inventions ever made. That which James Clerk Maxwell had predicted in 1865 by mathematical analysis was demonstrated experimentally by Heinrich Hertz in 1886 and later, Marconi, availing himself of the researches of these two scientists, finally effected the electromagnetic wave system of wireless telegraphy in use today.

It is, indeed, a far stretch between Marconi's first experiments and the Lafayette superpower radio station of today. On March 27, 1899, Marconi sent his first message across the English Channel—a distance of 32 miles. This feat astonished the world. Up to that time comparatively little comment had been made regarding Marconi's invention, but when he actually sent a message across the channel, the world sat up and took notice. The daily newspapers soon spread the news of the wonderful event broadcast. Twenty-two years have elapsed since that memorable day. Last September, during the preliminary tests, an operator at the Lafayette station in France pressed the transmitting key. At the same instant, an operator at Cavite, Philippine Islands, 8000 miles away, heard the signal clearly —as did also San Francisco, 7000 miles away; Balboa, Canal Zone; Bar Harbor, Maine, and Washington, D. C. The latter achievement created far less comment than did the sending of a message across the channel 22 yr. ago. Our senses, it seems, have become dulled to the marvelous.

Erected for the French Government by the United States Navy Department at a cost of $4,000,000, the Lafayette station represents the last word in "radio." Eight steel towers, each 832 ft. high, support the silicon-bronze antenna. One thousand kilowatt transmitting arcs arranged in duplicate furnish a high frequency current of 500 amp. to the antenna, which has a total area of 5,227,200 sq. ft. An impulse sent out from this station can be heard instantly at any point on the earth's surface. Every square mile—nay, every square inch—of the surface of the globe is reached by the electromagnetic waves radiated from this station.

It is difficult for the human mind to grasp this fact; it exceeds even the powers of imagination of the Arabian Nights. It is characteristic of the present age, however —an age of progress and development, in which only the laws and principles which govern its workings are absolutely immutable and unchangeable.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

New Model CO_2 Recorder Developed

COINCIDENT with the present acute interest in better boiler economy, a new model CO_2 recording equipment which embodies important improvements over superseding models has been placed upon the market. Chief among its advantages are remarkably quick action, greater accessibility and simplicity of parts and the economy of combining in one machine means for determining CO_2 simultaneously from any number of boilers, up to a total of six.

A single unit CO_2 equipment for one boiler consists of three principal parts, namely the CO_2 meter proper, a recorder and an auxiliary boiler front indicator. The meter is placed wherever most convenient. Its function is to actuate the boiler front indicator and recorder in the engineer's office.

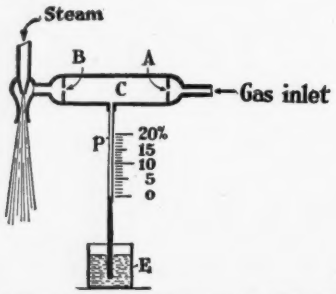


FIG. 1. ILLUSTRATING PRINCIPLE OF OPERATION OF CO_2 METER

The flue gas is analyzed, that is the CO_2 is extracted, in the meter. The principle involved in the operation of this machine depends upon the change in pressure caused by a change in volume in a stream of gas flowing through two apertures. Referring to Fig. 1, gas is caused to flow continuously through first aperture A and then B by means of an aspirator or syphon. A reduction of the gas volume between the two apertures, by absorption of the CO_2 content, causes a change of pressure or tension in chamber C which is transmitted to recorder and indicator, calibrated in per cent CO_2.

The CO_2 meter consists essentially of a cylindrical regulator on which is mounted the analyzing mechanism. This regulator maintains constant the suction created by the aspirator, thereby eliminating all changes in tension between apertures A and B except those caused by absorption within chamber C. It is the latter changes in tension which the indicator and recorder register.

Suction in chamber C actuates the recorder and indicator instantaneously and continuously. The only appreciable lag was formerly in the travel of the gas from boiler to chamber C. In the new model, the gas travel is hastened by utilizing the main aspirator's exhaust in an auxiliary aspirator for the purpose of drawing the gas from the boiler up to the absorption chamber while the main aspirator draws the gas sample through the absorption chamber.

With each unit is included a preliminary filter which removes soot and dirt from the sample before it reaches the intermediate and final filters on the machine. This has been redesigned so that the filter chamber can be conveniently cleaned in a few seconds without interrupting operation of the machine.

Multiple equipments combine in a single outfit means for measuring CO_2 from two, three, four, five or six boilers independently and simultaneously. It is most economical to equip the boilers in batteries of six each, but this is not absolutely necessary, inasmuch as the CO_2 meters are now built on the "unit" or "section" plan and may be added to from time to time.

With multiple unit machines, each boiler is equipped, as previously mentioned, with its own recorder, auxiliary boiler front indicator, preliminary filter, and absorbent chamber with necessary appurtenances, but the aspirator and other parts of the master unit serve all units in common. A six-unit meter is illustrated in Fig. 2.

The recorder, Fig. 3, operates on the hydrostatic principle, by which all springs, levers and joint movements are avoided. It makes a continuous (not intermittent) record of the per cent CO_2, furnishing an autographic history of the operation of each boiler for every second of the day, showing when fires receive attention; when and how often furnace doors are opened, or how often stoker speed and fuel-bed thickness are changed; fires broken and cleaned; effects of changes in damper regulation and methods of firing.

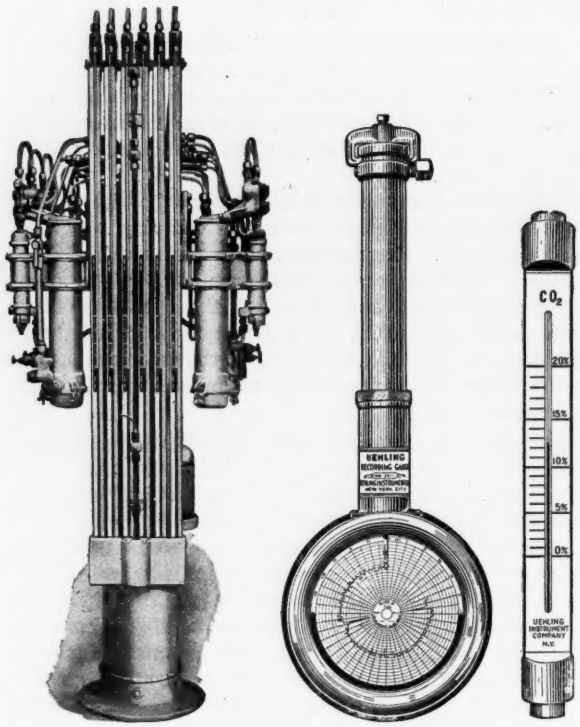


FIG. 2. STANDARD SIX-UNIT CO_2 METER

FIG. 3. RECORDING GAGE FOR USE IN CONNECTION WITH CO_2 METER

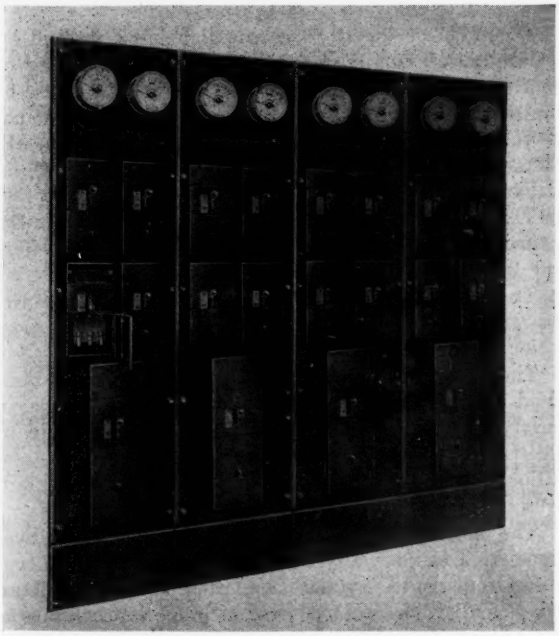
FIG. 4. CO_2 INDICATOR FOR BOILER FRONT

The boiler-front indicator guides the fireman in supplying just the right amount of air to burn the fuel with the least loss of heat up the chimney.

IT MAY NOT be generally known that France is the richest country in iron ore in Europe, and that the United States is the only country in a position to challenge her for the leading position of the world. With the restoration of Alsace-Lorraine, it is estimated that the French output will be 45,000,000 tons of iron ore a year, of which 17,000,000 tons will be exportable.—Compressed Air.

A New Dead Front and Rear Switchboard

A RADICALLY new type of switchboard which provides complete safety to the operater has recently been manufactured. There are no exposed contacts of any kind, either front or rear, nor is it possible for the operator to reach live parts under any circumstances without dismantling part of the board. These boards are suitable for any capacity up to 600 amp., 250 v. direct current, and 1000 amp., 600 v., alternating current. They may be equipped with any number of switches, circuit breakers, meters and other switchboard instruments, and are applicable for hotels, office buildings, theaters, industrial plants, and for marine work.



DEAD FRONT AND REAR SWITCHBOARD

The board can be made up of any desired number of panels, each of which consists of a heavy sheet steel front, which is finished to resemble slate and is mounted on angle-iron supports with cross beams to make the construction rigid. Openings of the proper size are provided in the front and into these switches and other instruments are accurately fitted and supported by angle irons in the rear.

The switches are of the auto-lock type with all of the safety features retained. Each switch is in a separate compartment and is operated by a handle which projects through the cover, but is always dead. A door gives access to the fuses, but it is interlocked with the switch and cannot be opened unless the switch is in the off position and all accessible parts are dead. The switch cannot be closed while the door is open.

In addition to the fuse door, each switch has a cover which is held in place by screws. The removal of this cover gives access to the bus-bar connections and switch mechanism for inspecting the switch contacts, for making load tests of motor circuits without interrupting the service, and for renewing or repairing the switch. All parts are removable from the front. The bus-bar connections are made through studs which connect with the stationary switch contacts. Because of this construction, there is little need to go behind the board and the rear projection is small, so that it can be placed very close to the wall. Suitable pull boxes can be provided at the top or the bottom of the board if required.

Europe Using Semi-Coke

HARD thinking arising out of the lessons of the war has brought about some unusually interesting developments in engineering abroad according to George E. Learnard, the president of the Combustion Engineering Corporation, who is at present in Europe in connection with the business of the newly formed International Combustion Engineering Corporation. He has sent the following interesting comments and observations on conditions in the combustion field in Europe.

"Although, when I left the United States, I felt that through our correspondence and affiliated companies I was well advised of the progress in European countries in the field of combustion engineering, which field encompasses a more efficient utilization of raw fuel and labor-saving devices, wherever steam is made or fuel is burned, I am nevertheless surprised by what I have seen.

"I think engineers in the United States little appreciate the hard thinking on this side arising out of the lessons of the war.

"That countries, such as England and France, having no deposits of oil, and, in the case of England, insignificant water power, should be devoting close attention to the extraction of oil from coal and to the employment of semi-coke for steam raising and for furnaces, was to be expected when we remember that one of the chief lessons of the war was that a country without oil is in a dangerous position.

"Another lesson arising out of the war, namely, the necessity of labor-saving devices to compensate for the reduced man power of the European countries, has seemingly been taken to heart, and I have seen here certain devices toward labor-saving in boiler rooms beyond anything known to me in the United States. Even under the present conditions of ample labor supply, due to slackness in general trade, these devices are being pressed into use, for commercialism is obliged to yield to the growing pressure of public sentiment, as well as labor unions, toward the elimination of man-breaking and manual labor.

"As to the abstraction of oil from fuel, there is a considerable agitation in the country toward legislation making it compulsory that certain fuels should not be burned in their raw state, and that the light oils and certain tars should be extracted before they are used for furnace work or for steam raising. It is safe to forecast that in another ten years no highly bituminous coals in England will be burned in their raw state.

"While oil from bituminous coals is being extracted in England by one large company in considerable quantities, and on a commercial basis, by processes akin to well known American methods, the future, in my opinion, lies in two new inventions which are being experimented with and perfected in secret.

"One of these treats the fuel by internal heating in such a little space, and with such simplicity of mech-

anism, that the oil is extracted and the fuel reduced to semi-coke while it is progressing, steadily, by gravity from the main bunkers containing the raw fuel to the mechanical stoker hoppers. These mechanical stokers are specially adapted for receiving and burning the hot semi-coke from the interposed retort or distilling apparatus between the stoker hoppers and the main bunkers.

"The advantage of such a compact, self-contained, simple apparatus need not be seen to be appreciated. I am not permitted to elaborate or describe the detail of the apparatus more fully.

"The second method which I have investigated is of prime interest to those who are believers in the ultimate general employment of pulverized fuel for steam raising and furnace work.

"In this, the distillation of the fuel takes place while the fuel is being reduced to a powder, i.e., while it is being pulverized.

"Instead of this method for obtaining light oils and certain tars adding to the complication of pulverized fuel equipment, it appears, on the contrary, to simplify it, since the drier used in the ordinary pulverized fuel system disappears, and also since the powdered fuel, being in the form of semi-coke, enables it to be transported with a simplification of machinery or apparatus. Furthermore, this semi-coke is of such a character that it may be stored indefinitely without being affected by moisture or heat. The gases from the fuel in process of distillation are, in part, condensed to oil in the usual way, and the remainder carried to the furnace burners and injected into the furnace with the powdered semi-coke.

"Returning to the question of labor-saving devices in boiler rooms of the several called to my attention, decidedly the most interesting is an automatic ash conveyor for use in power stations, or wherever water-tube steam boilers or metallurgical furnaces are employed.

"It was my pleasure to examine one of these conveyors at work and I was indeed startled and astonished by its perfection of operation."

Power Test Codes

NINETEEN Power Test Codes, constituting what their framers style "a national common law" in the field of power plant testing are being framed by 125 leading engineers, scientists, and educators under the auspices of the American Society of Mechanical Engineers.

The codes, when completed, will affect a wide range of industrial enterprises, large and small. They will provide courses of procedure by which everything from an electrical superstation to a boiler feed pump shall be tested to see if they comply with the terms of purchase or if they are operating at the desired efficiency.

The codes when completed will constitute a revision and enlargement of the Power Test Codes of the American Society of Mechanical Engineers issued in 1915. This plan of revision was set in motion in 1918 when the Power Test Committee of the American Society of Mechanical Engineers was reorganized as a body to draft 19 new codes for the different classes of apparatus comprised in power plant equipment.

What is expected to be one of the most important public hearings and discussions held by engineers in many years will take place in Chicago during the sessions of the spring meeting of the American Society of Mechanical Engineers May 23-26. Three codes will be presented to the A. S. M. E. for consideration and adoption at this session.

The one of these which is probably of most general interest is officially known as "Test Code for Reciprocating Steam Engines." This discussion will relate to the adoption of the Power Test Code containing rules for conducting tests of steam engines and evaporating apparatus, and will be open to the public. Manufacturers, members of engineering societies and technical and scientific men from every city are planning to give their views on the question of adoption of these codes prior to their final sanction by the American Society of Mechanical Engineers.

The third of the 19 to be completed is described by the committee as intended primarily for the testing of apparatus heated by steam, such as vacuum pans, or single and multiple-effect evaporators. The principal use for such evaporators is in the manufacture of alkali, salt, sugar, condensed milk, extracts from chemicals, and similar processes.

Three codes have already been completed; one, in the nature of a preliminary set of rules, is entitled "General Instructions."

The committees are drawing upon individuals, societies and many other agencies outside the American Society of Mechanical Engineers.

The Committee on Hydraulic Power Plants is composed of three representatives each from the American Society of Civil Engineers, the American Institute of Electrical Engineers, the National Electric Light Association and the American Society of Mechanical Engineers.

The Mechanical Section of the American Railroad Association has officially designated A. W. Gibbs to represent that body on the Committee on Locomotives. Other individual committees include representatives from the U. S. Bureau of Standards, the U. S. Naval Academy Testing Station, Machinery Builders Society, the Hydraulic Society and the American Society of Refrigerating Engineers.

"The purpose of the Power Test Codes," says an official statement by the society, "is to provide standard directions for conducting and reporting performance tests of power plant and heat apparatus, such as are most commonly undertaken in commercial work. They are sufficiently comprehensive to apply to tests which determine all the details of the performance, but selected parts of the code may be used for tests of limited scope. They apply further tests which concern the fulfillment of performance guarantees and to acceptance tests.

"The codes are not intended to supply directions for general research or the development of equipment or of processes. It is assumed that the engineer who is concerned with research will proceed as nearly as practicably in harmony with their requirements and that in the publication of results he will employ forms of presentation which will be comparable with those of the codes."

News Notes

THE SUPERHEATER Co. announces that after May 1, 1921, its general offices will be moved from 30 Church St., to 17 East 42nd St., New York City.

THE AMERICAN ENGINEERING Co., of Philadelphia has established a mid-western service station at Detroit, Mich., where a complete stock of parts for equipment of its manufacture is carried and from which immediate shipments will be made.

JAS. ROWLAND BIBBINS has recently resigned as supervising engineer of the Arnold Company, Chicago, to accept an appointment as manager of the Department of Transportation and Communication of the United States Chamber of Commerce, Washington, D. C. He assumed his new duties on April 1 at Washington headquarters in the Mills Building.

WILLIAM PESTELL, formerly western sales manager of the Sanford Riley Stoker Co., with headquarters in Chicago, now becomes sales manager with headquarters in New York City. W. L. Bigelow becomes district manager of the Pittsburgh territory, while C. Lincoln Smith goes to Cincinnati in the same capacity. To better serve the territory in and around Kansas City, the F. M. Beeson Machinery Co., Kansas City, Mo., have been appointed sales agents for the company. Sales in Denver territory will be handled by Stearns-Roger Mfg. Co., Denver, Colo.

THE L. J. WING MFG. Co. will move during the month of May from its present location in New York City to a new building just completed in Newark, N. J. The new building will house offices and factory and will give over 50 per cent more space than it now has, with ample ground space around the building for present storage and future expansion. The new Wing home will be modern in every respect, with railroad siding and greatly increased factory and office area.

AFTER considerable uncertainty over the selection of a suitable building, it has been announced that the New York Electrical Exposition will be held at the 71st Regiment Armory, Park Ave. and 34th St., New York, during the 10 days beginning Sept. 28. As in former years, the 1921 show will feature electrical equipment for home, motor-driven machinery for industrial purposes, electrically operated material handling machinery, and electric vehicles.

THE DEPARTMENT OF THE INTERIOR is making a survey of the coal stocks which are being carried over from the past coal year in order that consumers and producers may make intelligent plans for the coming year. This report will supplement the Geological Survey's weekly coal report, the last of which indicated that 6,468,000 tons were produced in the third week of March as compared with the weekly average of 1920 of 10,700,000 tons. The report should be ready by May 1.

THE STOKER MANUFACTURERS ASSOCIATION will hold its annual meeting this year at the Red Lion Inn, Stockbridge, Mass., May 24, 25 and 26. The association plans to take up some very important matters at this meeting. For some time past, the Engineering Committee has been working on a Universal Coal Analysis. They have also given considerable thought to the subject of a standard Minimum Setting height for each type of boiler. These matters, together with many others of considerable interest to the association, will be brought up and discussed at the meeting. This annual meeting should be most interesting and the results of the work that the various committees have been doing for the past year, will undoubtedly be of material benefit to the combustion field.

THE HEARINGS on Mar. 25 indicated that amendments to Federal Power Commission rules recently issued, would be required. The proposed amendments relate chiefly to methods and amounts of depreciation and amortization reserves and to the application of a system of accounts to be adopted by the commission. These particular recommendations were laid before the commission by the representatives of the National Electric Light Association, the American Gas Association, banking houses and power companies. Fitting amendments to the regulations will be decided upon by the American Engineering Council and affixed to those now in use. One hundred and ninety-eight applications have been received to date and 12 projects requiring licenses or permits were advertised during the last week in March.

A HUGE hydroelectric plant to cost $3,000,000 or more is to be located at Shamokin Dam, Pa., according to plans of the Pennsylvania Power & Light Co. The old Pennsylvania Coal Co. dam, which spans the Susquehanna River between this point and Sunbury, is to be utilized and the big plant would be erected just below what is known as the "lockhouse," where there is a fall in the water.

It is declared that the enormous use of coal by the power company at its eleven central Pennsylvania towns would be stopped.

BIDS for the erection of a power plant at Melbourne, Australia, are requested from Pittsburgh manufacturers in a communication received recently by R. J. Seamon, manager of the Trade and Industrial Bureau of the Pittsburgh Chamber of Commerce. Similar requests have also been sent to the chambers of commerce of Chicago and New York.

SECRETARY OF WAR has announced after investigation that if responsible persons can be found to take over its operation on a reasonable return to the government, a recommendation will be forwarded to Congress for appropriation sufficient to complete the Muscle Shoals Water Power (Wilson dam) project. Requirements are now $30,000,000.

THE MURCH BROTHERS' CONSTRUCTION Co., of St. Louis, recently secured Treasury Department contract for the construction of a power house at the Government Hospital at Dawson Springs, Ky., on its bid of $42,000.

GRAY & MURDOCK, of Salt Lake, were awarded the contract to install the new municipal electric light and power system for Brigham City, Utah. The award was made at a special meeting of the city council recently at which representatives of many of the firms which had submitted bids on the project were present.

The total amount of the bid is $95,387, and the specifications call for a redwood stave pipe line, cement

intake, cement and brick power house. This contract was awarded on what the specifications term schedule No. 3, and includes also the setting of the machinery in the power house.

The Westinghouse Electric & Manufacturing Co. was awarded the contract to furnish the electrical equipment for $15,695, and also the contract for the installation of the electric and hydraulic equipment, including the switchboard, for $2498 plus the bond in each case.

The grade for the pipe line, which will be entirely exposed and laid on wood saddles so that the earth will not come in contact with it at any point, is all completed, so that the contractor can begin operations immediately. The entire job will be completed by August.

ERECTION of a $50,000 power house at the Manchester plant of the Whitaker-Glessner Co. is planned according to application for a building permit, filed recently with the city permit clerk at Wheeling, Pa.

The plant would be 104 by 140 ft., two stories and basement, of structural steel. It is planned to start work on the plant at once.

ANNOUNCEMENT has just been received of the issuance of the first preliminary permit for the development of hydroelectric power in North Carolina. The permit was issued to the United Mills Co. of Hickory and gives that company the right to construct dams, power houses, and transmission lines on Harpers Creek, Caldwell County, to generate approximately 1400 hp. of electric power to be used for running a cotton mill and public utility in Mortimer.

Since the creation of the federal power commission by Congress last fall, the right to develop commercial water powers in the states which do not have a power commission must be obtained from the national commission. As North Carolina does not have a power commission, the federal commission regulates all hydroelectric developments in that state.

PLANS are being perfected for an immediate $3,000,000 enlargement of the Kansas City Power & Light Co.'s new power house at the foot of Brooklyn Ave. The company will expend $1,700,000 in adding to the generating portion of the plant and about $1,300,000 in a boiler room addition.

The company is negotiating for the purchase of a 30,000-kw. turbo generator. The extension of the generating departments will afford space for two such machines, but the purchase of only one is included in the immediate $3,000,000 program.

The generating equipment at present consists of three 20,000-kw. generators.

It is estimated that the building can be enlarged and a new turbo generator installed by fall, but that the boiler additions cannot be completed before the summer of 1922.

U. S. CIVIL SERVICE COMMISSION announces an examination for assistant examiner, Patent Office, on May 11, 12 and 13, to fill vacancies in the Patent Office, Washington, D. C., at the entrance salary of $1500 a year, with the increase granted by Congress of $20 a month to appointees who perform satisfactory service, and vacancies in positions requiring similar qualifications, at this or higher or lower salaries. Applicants must have reached their twentieth but not their seventieth birthday on the date of the examination. In view of the retirement act, at the request of the appointing officer certification will not be made of eligibles who have reached their fifty-fifth birthday. Apply for Form 1312, stating examination title.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.,

required by the Act of Congress of Aug. 24, 1912, of Power Plant Engineering, published semi-monthly, at Chicago, Ill., for April 1, 1921.

State of Illinois } ss.
County of Cook }

Before me, a Notary in and for the state and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of Aug. 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reserve of this form, to-wit:

1. That the names and addresses of the publisher, editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.

Editor, Arthur L. Rice, Chicago, Ill.

Managing Editor, none.

Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of the stockholders owning or holding 1 per cent or more of the total amount of stock.)

Technical Publishing Co., Chicago, Ill.

E. R. Shaw, Chicago, Ill.

A. L. Rice, Chicago, Ill.

A. E. Rice, Wilmette, Ill.

Charles S. Clarke, Wilmette, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above, giving the names of owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in case where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest, direct or indirect, in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is ..... (This information is required from daily publications only.)

Chas. Sanford Clarke, Secretary.

Sworn to and subscribed before me this 22d day of March, 1921. Ella O. Klein.

(SEAL) (My commission expires April 9, 1923.)

NOTE.—This statement must be made in duplicate and both copies delivered by the publisher to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the postoffice. The publisher must publish a copy of this statement in the second issue printed next after its filing.